JANUARY 1943

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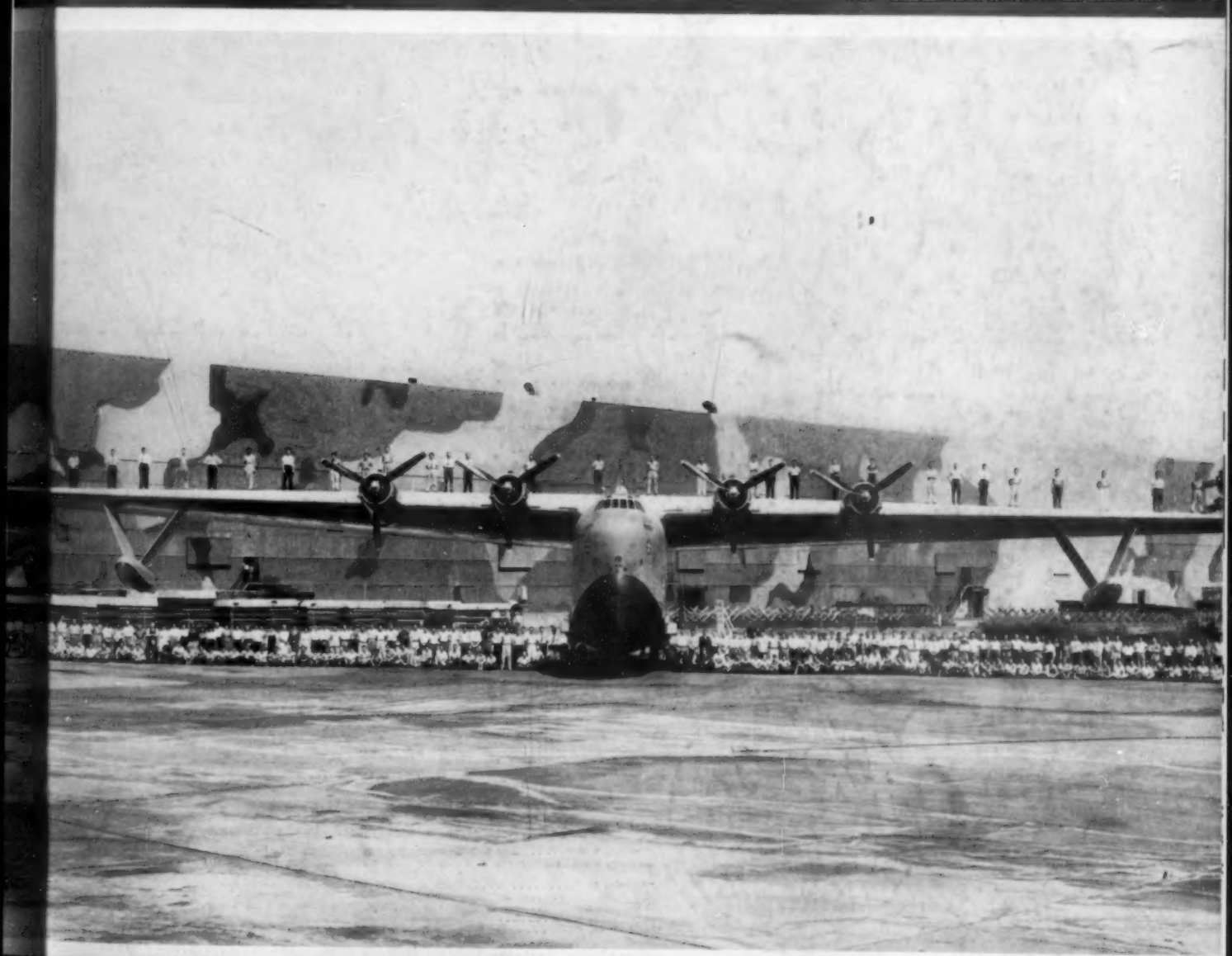
The WELDING Journal



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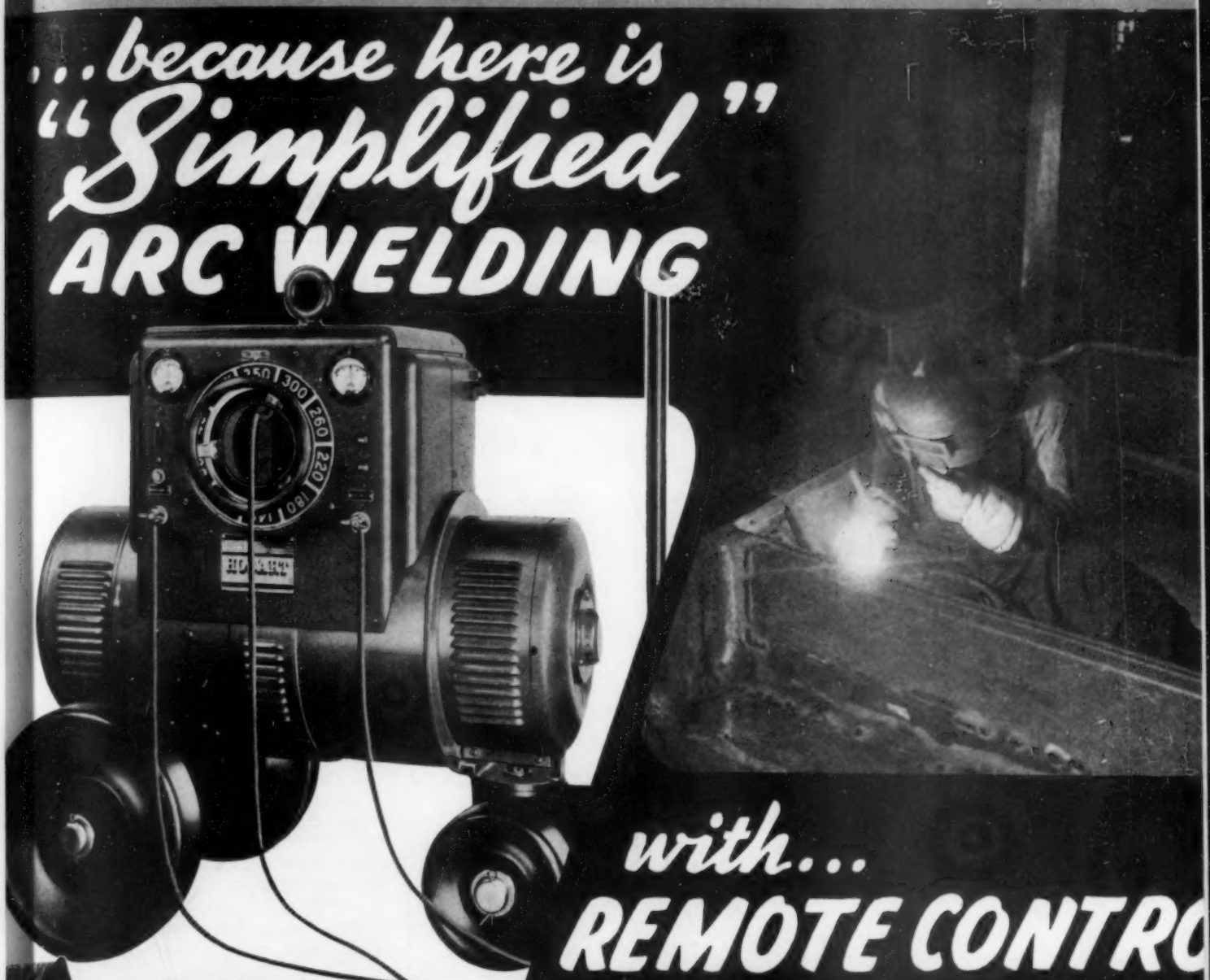

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Published for the Advancement of the Science and Art of Welding

W. SPRARAGEN, Editor

JANUARY 1943

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COVER

The mighty Martin Mars, 70-ton Navy flying boat containing hundreds of welded sections, and the biggest ship of her type in the world. *Courtesy The Glenn L. Martin Company.*

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CONTENTS

TECHNICAL PAPERS, ITEMS AND REPORTS

Salvage Is the Answer to Scarcity of Replacement Parts, by R. B. Aitchison 5
The Application of Welding in Submarine Construction, by E. H. Ewertz and R. D. West 10
Principles of Shrinking and Straightening Distorted Low Carbon Steel Used in Shipbuilding, by Matt D. Offen 14
Radiographic Inspection Technique Applied to Special Welding Problems, by Don M. McCutcheon ... 16
New Developments in Flame Hardening, by Stephen Smith 21
Designing for Production Welding, by H. A. Oldenkamp 24
Application of Series Capacitors to Resistance Welding Machines, by R. M. Partington 26
X-Ray Method vs. Guided Bend Method of Testing Electric Arc Welders, by C. G. Lutts, S. D. Herbein and L. W. Pote 31
Current Welding Literature 34

SOCIETY AND RELATED ACTIVITIES

Technical Appointments 36
Second Annual Science Talent Search Opens 36
Membership Activities 36
Production Welding Course to Be Held in Cleveland 36
Welding Classes at Edward G. Budd Plant 36
We Remember 36
The Institute of Metals 38
Tin Solders 38
Spot Welding Saves Time and Material in Production of G-E Switchgear 38
Advertising Index 39
400 Miles on 4 Gallons of Gas 42
Specific Heats 42
Huston Assistant to President, Lukens Steel Co. 42
New Booklet on A.-C. Welding 44
I.A.A. Publications 44
New Radial Portable Spot Welder 44
Spot Welds in Switchgear Construction 44
New Award Program for Engineering Students Announced by Lincoln Foundation 44
Mills Helps Industry Integration 46
Obituary—John E. Greiner 46
Obituary—Dr. F. M. Becket 48
Gear Set Welding 48
Manhole Covers 50
Dredge Ladder 50
Photos of Arc-Welding Jobs in Brazil 52
Induction Heat Saves Time in Brazing Operation 52
Shipbuilding—"Liberty" Ships 52
Deland Pool: Aircraft Construction Class 52
New Products 54
Section Activities 58
Employment Service Bulletin 63
Obituary—Chester F. Gailor 63
How to Salvage Tools 63
List of New Members 63

WELDING RESEARCH SUPPLEMENT

Welding Research Committee Reorganized 1-s
Physics of the Arc and the Transfer of Metal in Arc Welding, by W. Spraragen and B. A. Lengyel 2-s
Fatigue Tests of Full Thickness Plates With and Without Butt Welds. Discussion by A. B. Bagsar 42-s
The Magnetic Powder Method of Inspecting Weldments, and Castings for Subsurface Defects, by Carlton H. Hastings 43-s
Structure of Butt-Welded Steel Tubing, by H. J. Mastenbrook and H. J. Steffen 51-s

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Salvage Is the Answer to Scarcity of Replacement Parts

By R. B. Aitchison†

TODAY'S all-out production by American industry is creating many problems not the least of which are those caused by the increased rate of wear of equipment parts. Scarcity of replacement parts makes the problems particularly difficult to solve. More than ever before, therefore, there is a need for oxyacetylene welding and cutting for salvaging and repairing worn and broken parts whenever possible. The full use of the blowpipe in repair and maintenance of these parts will keep production going at top speed with the shortest possible time out for inevitable repairs, and often with increased service life for the repaired parts.

The advantages of the oxyacetylene process in repairing breaks quickly and dependably, in rebuilding worn parts, and often in fabricating the replacement parts themselves, have long been known to industry. Each industry has become familiar with techniques and applications that are special to its field. Today, however, there is hardly an industry that has not expanded greatly or switched to new and different types of production, and often these plants are not fully aware of the possibilities that oxyacetylene welding and cutting offer with respect to their new types of equipment.

On the following pages are illustrated a few typical parts repaired by the oxyacetylene process. They should prove helpful particularly to the industries now engaged in new lines by suggesting what type of parts can be salvaged.

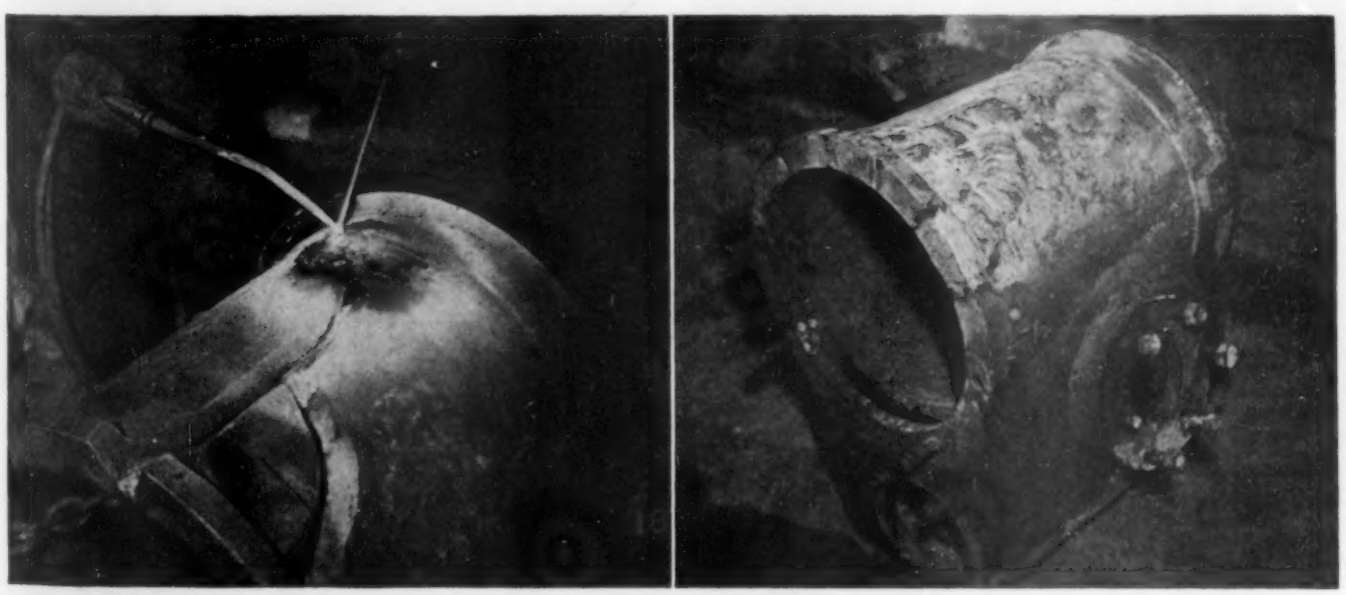
† The Linde Air Products Company, New York, N. Y.

Gears—Broken Spokes, Hubs and Rims
(Fig. 3)

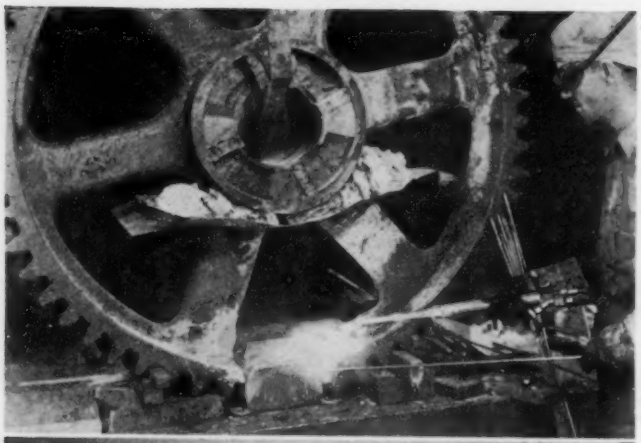
Fractured spokes, hubs and rims of gears can usually be repaired by bronze welding. The 6-ft. cast-iron bull gear for a punch press, shown in the illustration, had a broken rim, 2 broken teeth and 4 broken spokes. It was reclaimed by bronze welding and carefully controlled preheating. The problem of expansion and contraction was greatly simplified by suspending a pack of wet asbestos under the hub.

Gears—Worn and Broken Teeth
(Fig. 4)

Worn or broken gear teeth can be built up by bronze welding so accurately that often no subsequent machining is required. Usually a little filing is all that is neces-



Figs. 1 & 2—This Hoisting Engine Cylinder, Which Froze and Cracked in Cold Weather, Was Salvaged from the Scrap Heap by Bronze Welding



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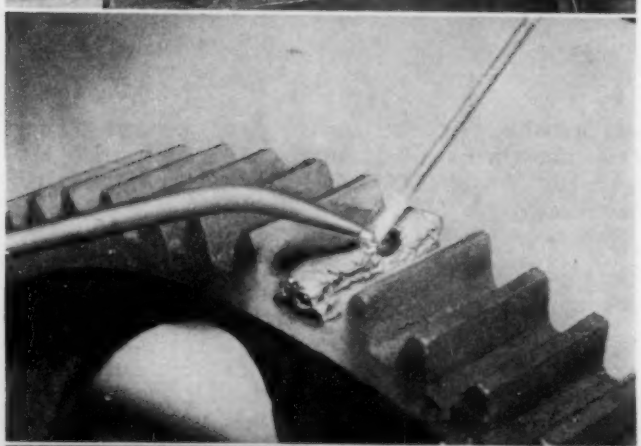

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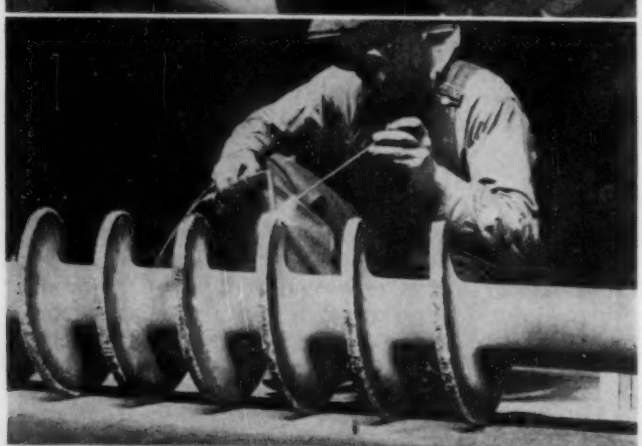

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sary, and frequently the repair can be done in position, eliminating the cost and delay of dismantling. The tooth of the spur gear in the illustration is being rebuilt by depositing successive layers of bronze welding rod each $^{1}/_{16}$ in. thick.

Screw Conveyors
(Fig. 5)

The edges of this worn screw conveyor flight were built up $^{3}/_{4}$ in. with bronze welding rod. No difficulty was experienced in holding the weld to rather close tolerances, which was necessary because the flight was too long to place in a lathe for finishing. The operator started at one end and kept turning the flight as he progressed so that welding was always done in a flat position. Hard-facing rod is often used to rebuild worn flights of this type.

Sheaves
(Fig. 6)

These sheave wheels used on an aerial tramway were reclaimed by bronze welding. The rebuilt surfaces actually outlast the original cast-iron base metal and cause considerably less wear on the cables. The wheel on the left is shown as-welded; that on the right has been finished and is ready to be returned to service.

Machine Frames
(Fig. 7)

The bronze-welded repair of this 13-ton cap casting for a 100-ton press saved a manufacturer a three weeks' shutdown. After veeing the 14 ft. of cracks in the 4-in. and 6-in. thick metal, the entire casting was set on I-beams to insure exact alignment, and preheated with charcoal in a firebrick furnace. Almost 400 lb. of bronze welding rod was required for the repair.

Expansion Reamers
(Fig. 8)

These reamers were broken by overexpansion. The two at the right have been repaired by bronze welding; those at the left have been ground along the cracks preparatory to welding. After beveling by grinding, broken sections are aligned, and a paste of asbestos and water is then packed around the reamer blades to act as protection against heat during welding. Instead of scrapping broken reamers, machine shops find that they can reclaim them for a fraction of the original cost.

Valves—Worn Seating Surfaces
(Fig. 9)

Worn seating surfaces of all types of gate and globe valves can be rebuilt with bronze welding rod and hard-facing rods. In the illustration, the disk for a 12-in. gate valve is being salvaged by depositing a $^{1}/_{8}$-in. thick layer of bronze on the worn seating surface. The disk was first faced in a lathe, then preheated to a dull red. After welding, the bronze deposit is machined to size.

Valves—Fractured Bodies
(Fig. 10)

Replacement of the fractured cast-iron body of this 6-in. gate valve (shown as-welded) would have taken several days, but repair by bronze welding returned it to service in 6 hr., greatly reducing shutdown time for the

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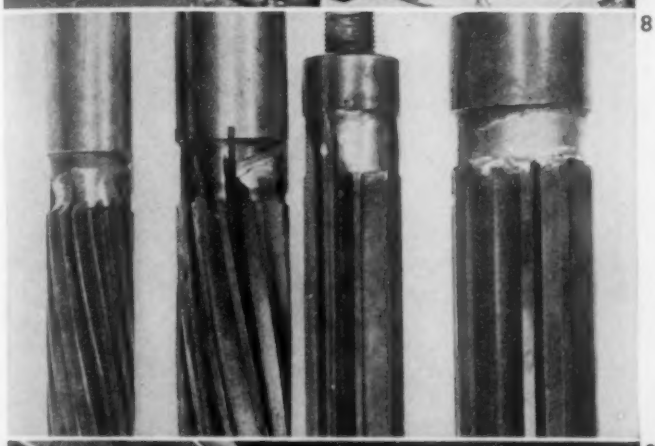
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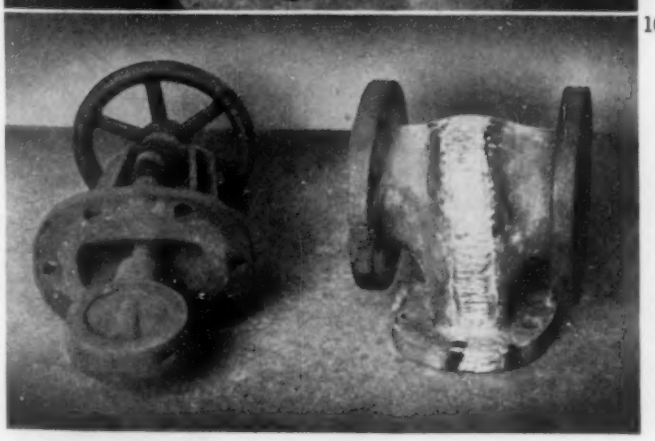
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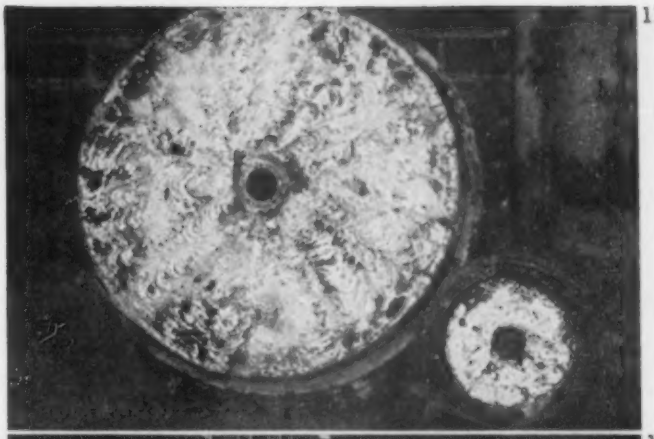
line. After dismantling, the broken parts were veed by chipping and grinding, then aligned and tack welded. Local preheating with the blowpipe was followed by the bronze-welding operation.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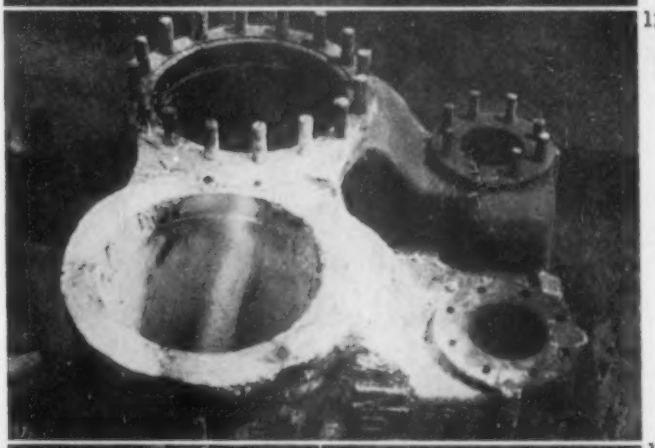
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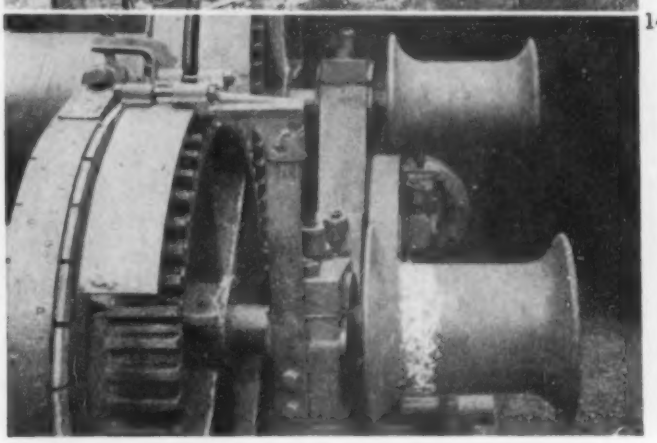
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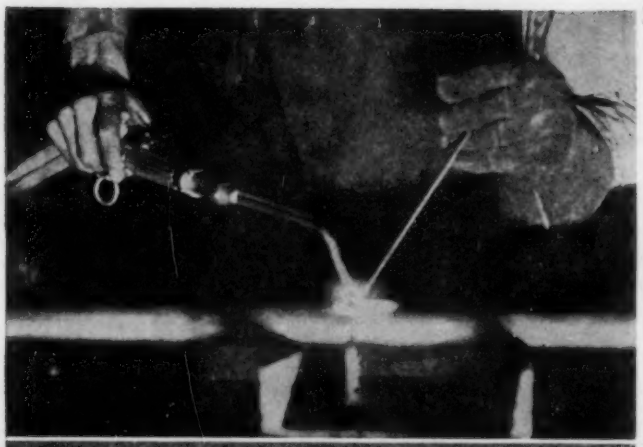
Pumps—Worn Surfaces

(Fig. 11)

Resurfacing centrifugal pump housings and other pump parts with bronze reduces maintenance and pro-



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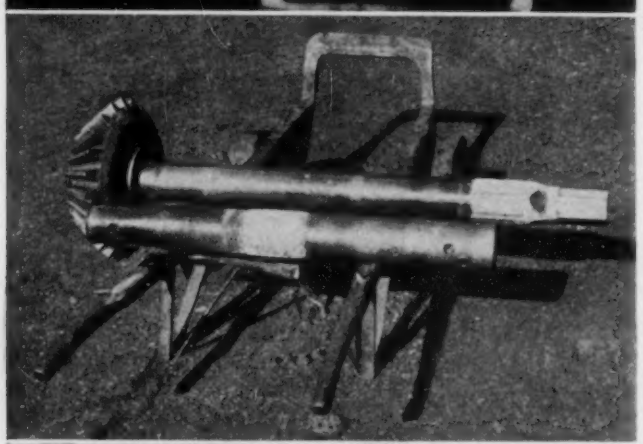

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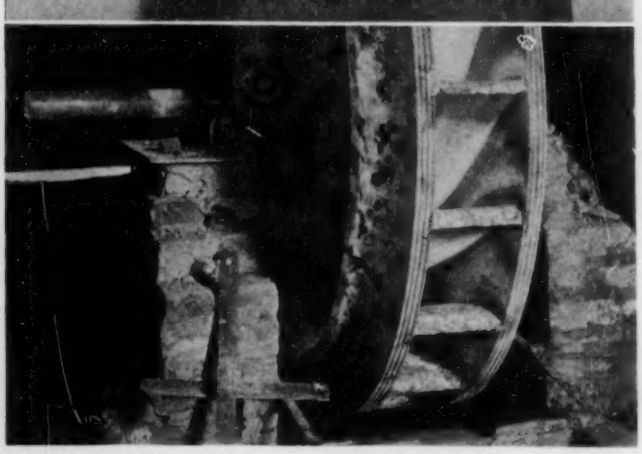

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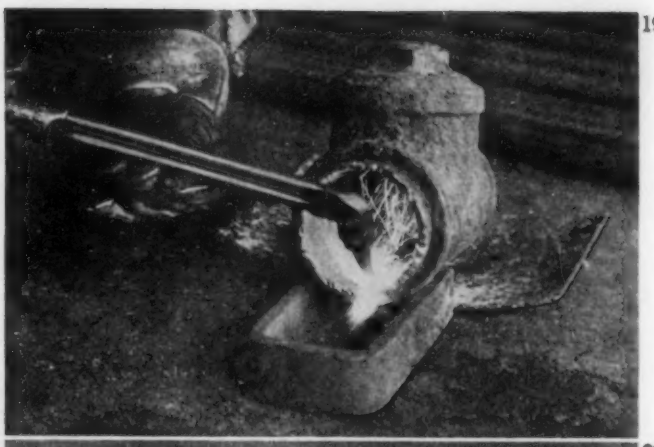

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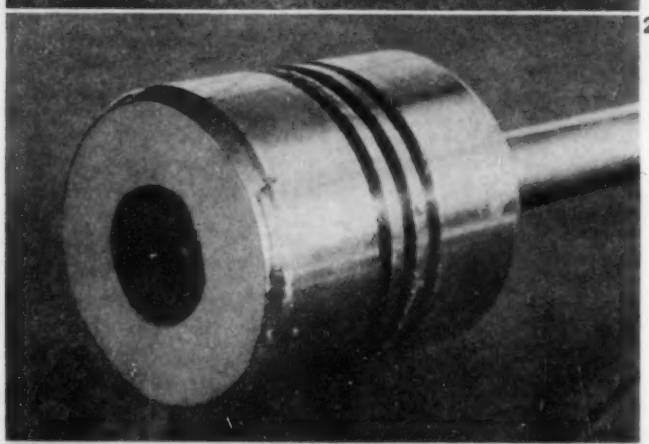

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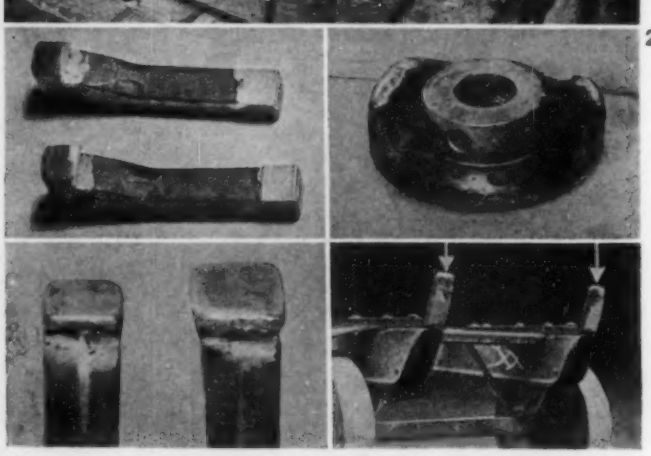

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longs service life, since bronze is highly resistant both to wear and to corrosion. The cast-iron pump parts shown have been bronze surfaced and are ready for machining.

Pumps—Fractured Bodies
(Fig. 12)

When one of the piston rods failed in service, the

piston crashed through the steam end of this pump, carrying away sizable sections of the 4-ton casting. Although the casting appeared to be destined for the scrap pile, complete repair was effected by veeing all cracks, preheating to a black heat, bronze welding, reheating, and slow cooling. The repaired casting is shown as-welded, prior to machining.

Foundry Flasks
(Fig. 13)

The unusually rough handling received by foundry flasks causes heavy damage—side walls are cracked, hinges are broken, lugs are knocked off, fins, webs and ribs are damaged, holes for registry pins become worn. They are easily salvaged by bronze welding, without preheating and usually without beveling or chamfering.

Winches
(Fig. 14)

Uninterrupted service is usually vital wherever hoisting equipment is in operation. Welding apparatus is insurance against costly delays caused by cracked or broken frames, bed plates, anchor bolts, gears or engine cylinders, and worn or grooved cable drums. Here, the worn spool of a pile-driver winch has been rebuilt with bronze rod.

Shafting—Broken and Bent
(Fig. 15)

Broken and bent shafts can be repaired with the welding blowpipe. In this photograph, the operator is welding a fractured shaft with high-test steel rod. A bent shaft can often be straightened by alternately heating and cooling the outside of the bend until the shaft is again true.

Shafting—Worn Bearing Areas
(Fig. 16)

Worn bearing areas of these drive shafts for a crane were rebuilt without distortion with bronze rod. Each of the worn areas, which measure approximately 6 in. in length and 5 in. in diam., required 8 lb. of bronze rod. The shafts are shown after bronze surfacing and before machining.

Shovels
(Fig. 17)

The life of a scoop shovel can be increased from 4 to 6 times by hard facing. Two bands were deposited, each 4 or 5 in. long, $^1/_8$ in. thick and about 1 in. apart on each face of the heel. The operation takes only 10 min. and requires about 12 in. of a $^1/_4$-in. rod of the hard-facing material. Finishing is not necessary.

Water Wheels
(Fig. 18)

The blades of this water wheel became worn down at the edges to such an extent that the wheel efficiency was materially reduced. Bronze welding rod was applied by means of a welding blowpipe until the edges were completely restored to their original size and the water wheel was replaced in service with a minimum of delay and with assurance that its life was appreciably extended.

Pipe Fittings
(Fig. 19)

With the oxyacetylene cutting blowpipe and a standard gouging nozzle, pipe stubs or "dutchmen" can be quickly and easily removed from salvaged valves, collars, tees and other pipe fittings without injuring threads. Older methods of removing dutchmen are difficult, slow and often ruinous operations.

Pistons
(Fig. 20)

A wide variety of worn pistons can be rebuilt and given added life by bronze welding. Here, the $13^1/_2$-in. diam. piston for a gas compressor is shown with the bronze deposit machined and the piston ready for service. After the piston was preheated, two operators rebuilt the worn surface to size by applying overlapping layers of bronze rod.

Engine Heads
(Fig. 21)

Typical of engine repairs is this firing head for a natural-gas engine. Cracked from overheating, the head was repaired by veeing the cracks, preheating with natural gas in a firebrick furnace, applying bronze rod, reheating and slow cooling. Scores of damaged heads have been salvaged by this procedure.

Miscellaneous Small Parts
(Fig. 22)

Oxyacetylene welding restores to efficient service countless small parts for machines and other plant equipment. Shown in the illustration are (upper left) hard-faced clutch fingers, (upper right) roller tripper rebuilt with cast iron rod, (lower left) chisels safe-ended with bronze rod, and (lower right) hard-faced hand truck skids.

1942 BOUND VOLUME

Bound Volumes of the JOURNAL of the Society for the year 1942 are now available with imitation black leather covers. Contains a wealth of information on the latest developments in welding. Also contains Subject and Authors' Index. Price, $5.00 plus postage to members; $6.50 to non-members plus postage.

The Application of Welding in Submarine Construction*

By E. H. Ewertz† and R. D. West‡

A REQUEST for a paper on the application of welding in submarine construction has been made the past few years but I found it impractical to comply with the request as the Navy Department could not permit any publicity of that nature. This year, however, I am in a somewhat different position, in that a paper could be written on the construction methods and procedures as established by the Manitowoc Shipbuilding Company, builders of thirty submarines—a paper that embodies, I believe, features of general interest to all concerned with welded construction, and Mr. Robert D. West, Superintendent of Naval Construction, in cooperation with myself have written such a paper and we hope you will find it instructive.

You will be particularly interested at this time to know that the best possible delivery dates for the first contract of ten submarines given the Manitowoc Shipbuilding Company—a Yard totally unfamiliar with the complicated submarine construction—was August 1945.

The Shipyard has developed remarkable aptitude and speed and we now find that they will deliver the first submarine nine months ahead of the set time.

E. H. EWERTZ

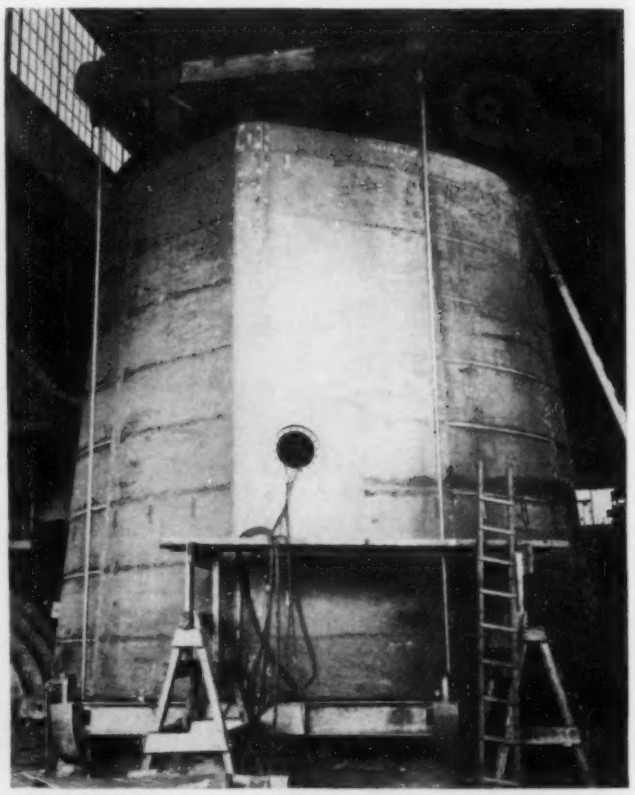


Fig. 1—Hull Section in Shop, Positioned on End to Permit Flat Welding of Certain Joints

Purpose

I. To discuss the present extent of welding in submarine construction, and possible future applications.

A. Main hull structure and its internal foundations and attachments are now entirely welded, with exception of certain removable plates required for machinery installation and of portions of superstructure. These exceptions are of minor importance and will probably remain at least partially riveted for maintenance and construction reasons. The few steel castings incorporated in the ship's structure, such as stern frame, hawse pipes are of a nature which would be difficult to reproduce as weldments. Naturally, modern submarines, through the weight savings that welding has realized, incorporate added functional features which would not otherwise be obtainable.

B. Various mechanical and piping systems at present contain an extremely large number of bronze and other non-ferrous castings for purposes of corrosion resistance. Due to the complicated nature of many of these castings, a considerable amount of non-ferrous casting repair welding is at present necessary to overcome minor casting defects, and major defects cause the rejection of a substantial number of such castings. Because these defects are often detected only after machining of the item in question has reached an advanced stage, further delays and expense are involved. Undoubtedly this situation could be alleviated considerably by the use in some places of weldment of various materials, possibly in conjunction with plastic and other non-corrosive coatings. At the same time savings in critical materials might be made.

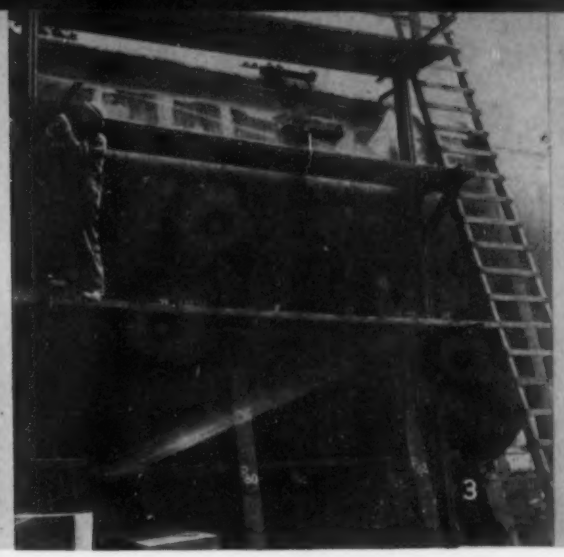
II. To discuss construction problems, methods and facilities as affected by welding.

A. Problems.

1. Complete hulls on building berths, with all interior foundations and structural attachments, rapidly, in order to allow early access by installation trades who have major portion of work and must do

* Presented at the A.W.S. Annual Meeting, Cleveland, Ohio, Oct. 12 to 15, 1942.

† Electric Boat Company, Manitowoc, Wis.
‡ Manitowoc Shipbuilding Company, Manitowoc, Wis.



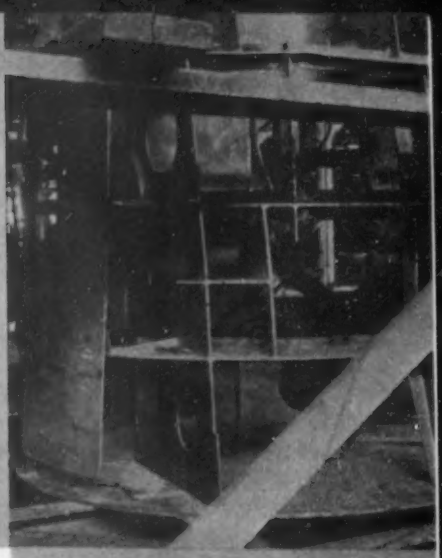


Fig. 2—Typical Hull Section, Being Transferred from Shop to Building Berth by Crawler Carrier

Fig. 3—View on Building Berth Showing Joints Between Shop Fabricated Sections, Prior to Weld ing

Fig. 4—One of the Smaller Hull Sections DuringAssembly in Shop

Fig. 5—Burning Machine Template Storage

Fig. 6—Portion of Small Part Shop Storage

Fig. 7—Small Weldments—Shop View

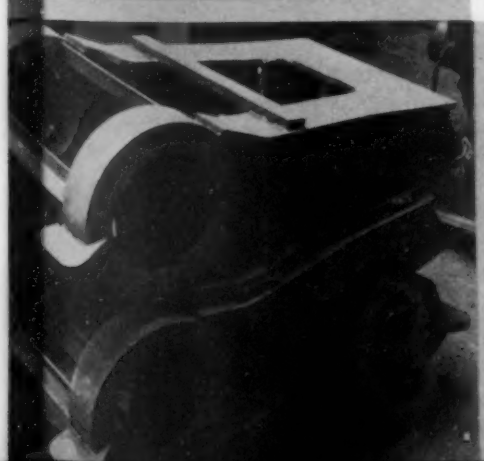
Fig. 8—Small Positioning Tables Used in Shop

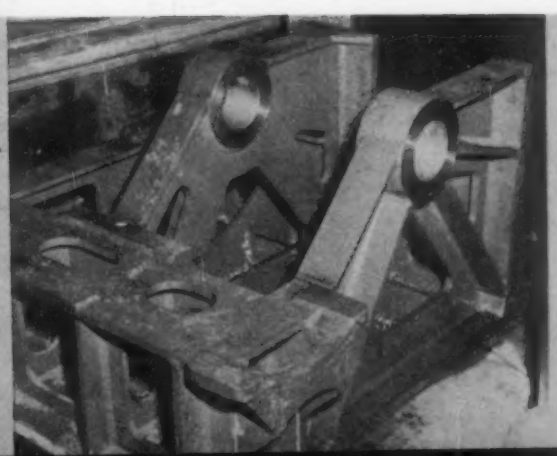
Fig. 9—Small Weldments—Shop View

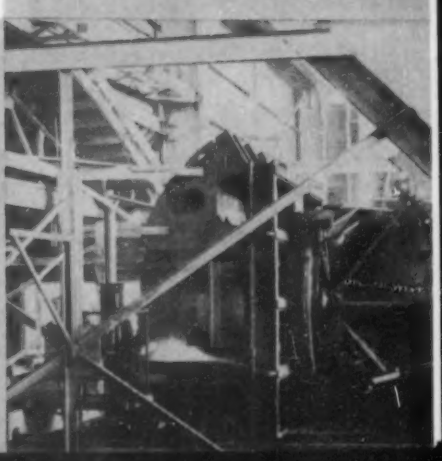
Fig. 10—A Machinery Foundation

Fig. 11—Large Positioning Tables, with Weldment on Same

Note that construction grid on which weldment was assembled bolts to positioning table top and helps to reduce welding distortion of piece. Power elevated platform is provided for welders.





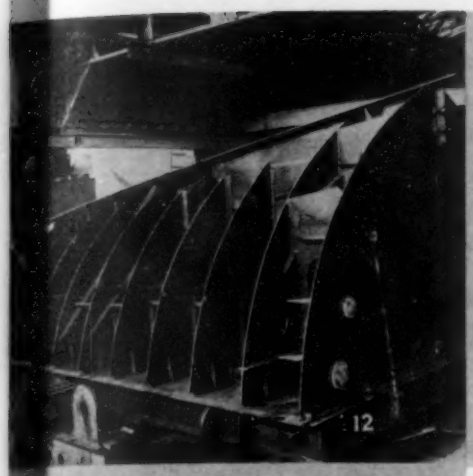


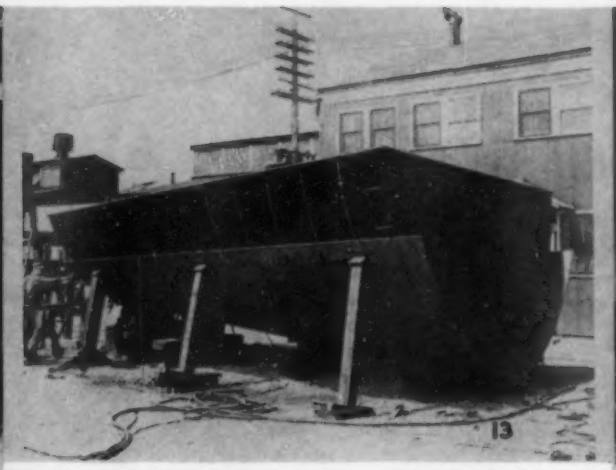
it in confined spaces. Limited number of building berths required earliest possible launching dates to obtain maximum output.

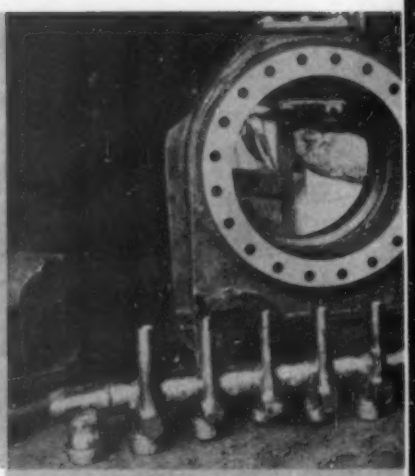
2. Hull and structural portion of each vessel, while not involving a large amount of steel, contains very little straight work, and a very large number of comparatively small shaped or irregular plates, bars and built-up sections. During and after fabrication keeping track of these parts is a considerable problem as well.
3. Highest quality of workmanship in welding and shipfitting is required in hull work, because of strength requirements and close clearances. Similarly, distortion and locked-up stresses must be minimized by suitable welding procedures and straightening operations and shrinkage allowances made.
4. Accelerated schedules required training of large amount of inexperienced labor and also training of supervisory force.

B. Methods used to meet above problems.

1. Maximum amount of work is done in shops so that Hull Department can complete its work on berth as soon as possible after keel laying.
   (*a*) Hull sections of maximum size that can be conveniently handled are completed in shop, weighing up to 65 tons. Same are complete portions of hull proper, later being divided transversely into approximately 16 major hull sections. As little erection and welding as possible is left for completion on building berths.
   (*b*) All miscellaneous weldments, such as machinery foundations, etc., which cannot be fitted to hull sections in shop are completed as far as possible in shop before being taken to berth.
2. Shop fabrication of parts was laid out to cover the following:
   (*a*) Complete planning and scheduling of all items through shop, by Hull Production Office.
   (*b*) Use of permanent templates wherever possible, and periodic checking of all wood molds.
      (1) To prevent reproduction errors due to change of template shape by atmospheric conditions.
      (2) To allow extensive use of automatic burning, or graphcut, machines.
         (i) To minimize shortage of skilled layout labor.
         (ii) To eliminate marking errors.
         (iii) For economy in cutting plates with irregular outlines.
   (*c*) Use of positioning table equipment of various sizes to enable comparatively inexperienced welders to obtain high quality work. Where assemblies are too large for positioning equipment, same are frequently positioned by shop cranes to permit downhand welding.
   (*d*) Setup and welding jigs are used on a few assemblies of which sufficient quantities were required to make the expenditure worth while. A considerable number of construction grids and platens, adaptable to a range of work, are used for assembly setup and welding. Wherever possible the jigs and grids are designed to be attached to welding positioners.
   (*e*) Hydraulic presses, with suitable dies, are used advantageously for forming certain specially shaped plates. Also, for some straightening operations. Ordinary slab methods are used for furnaced shell plating.
3. Subassembly System permits:
   (*a*) Positioning of considerable portion of work by welders and use of larger electrode sizes of so-called "hot rod" types.
   (*b*) More accurate fit-up of work by assemblers working from jigs or construction grids and platens.
   (*c*) Use of installation molds.
   (*d*) Straightening operations to take place on smaller, more readily handled units.
   (*e*) Minimizes locked-in stresses in completed structure because final assembly welding or attachment welding comes last. For same reason permits use of comparatively simple welding procedures.
   (*f*) Cumulative shrinkages are minimized. Shrinkage taken care of by final trimming of completed assembly before installation, or by simple allowances in original layout in some cases.
4. Personnel training of supervisory and labor forces involved:
   (*a*) Dividing work into a considerable number of categories, and distributing previously experienced workers among these categories, as leaders.
   (*b*) Use of Vocational School facilities for leader instruction.
   (*c*) Creation of specialist classifications of various grades for new employees, and upgrading of these new employees as specialists under supervision of leaders discussed above. Vocational School classes were set up to aid in this upgrading. In general, men previously experienced in other trades, such as carpenters, had no difficulty in learning to work with steel.
   (*d*) Welders were principal exception to above specialist training program, and followed a somewhat different setup.
      (1) Vocational Schools in surrounding area set up classes to train men for all position work. As soon as the trainees were







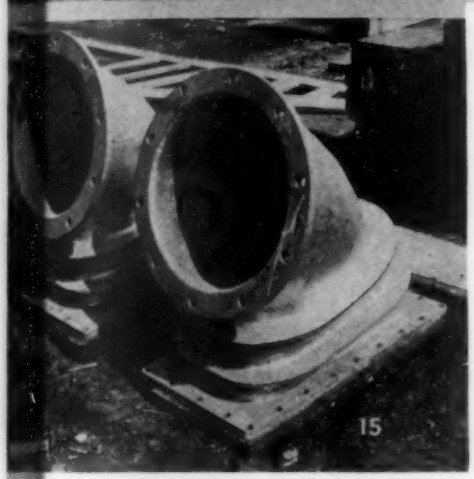


Fig. 12—Tank Top Assembly Under Construction in Shop

Fig. 13—Tank Top Assembly, with Portion of Shell Plating Attached, Ready for Building Berth

Fig. 14—Experimental Welded High-Pressure Manifold, and Welded Jacket on Bronze Casting

Fig. 15—Fabricated Elbows, Embodying Change from Circular to Rectangular Section

Fig. 16—Typical Fabricated Piping Weldments

sufficiently proficient, they were given standard Navy qualification tests under adequate supervision, as a requirement for shipyard employment.

(2) From date of employment, a work program was followed designed to upgrade men as rapidly as their responsiveness would permit, starting with tacking work on small assemblies, working through various types of shop work, to building berth work, and possible final promotion as leaders.

(3) Welding inspection, originally set up on Company Inspector System, was changed to foreman inspection system in order to pin responsibility for any poor work on man who did it. Final inspection is, of course, by Navy Inspectors so that foremen do not become lax.

C. Facility requirements, as affected by welding:

1. Large building berth crane capacity, as loads up to 65 tons must be handled. Where side launching is used, crawler crane equipment may be used instead of the more expensive overhead or track mounted types.
2. Adequate equipment for handling bulky and comparatively topheavy sections from shop to berths. A special wide tread crawler carrier performed satisfactorily after rubber tire mounted truck and trailer equipment was found to be dangerous.
3. Hull shop should have:
   (*a*) Heavy erection area having ample headroom and adequate overhead crane capacity.
   (*b*) Layout, fabrication and small subassembly area having a large number of small cranes, preferably floor controlled. This area need not have particularly wide bays, or high headroom, but should feed into the main erection floor area, and at the same time should be close to adequate outside storage areas.
   (*c*) Burning machine, positioning table, slab, roll, press, welding equipment, as previously discussed.
4. Welding equipment layout should provide maximum of flexibility on building berths, as a full welding crew is not required the full length of time a vessel is on the berth. Shop welding will require approximately 60 to 65% of the total welding man-hours, and berth welding 35 to 40%, and equipment requirements can be determined accordingly. Automatic welding equipment would have few applications.

Principles of Shrinking and Straightening Distorted Low Carbon Steel Used in Shipbuilding

By Matt D. Offen*

SHRINKING and straightening is one of the most exacting and complex jobs required of a shipbuilder. It involves knowledge of heat and quenching effects, carefulness, and it demands considerable forethought and experience.

It might be stated, in beginning, that investigations by scientists have proved that so many variable factors are associated with the heating of a piece of metal that it is impossible to know with any degree of certainty just how much that metal will expand or how much it will contract after heating or quenching. The shape of the object; how it was heated; how quenched; and, most important, what pressures or stresses are being forced upon it at the time such as weld pulls and warpage, or strongback straighteners—all have a great deal to do with the degree the metal will respond to the shrinkers' treatment. Remember the following figures and statements are not absolute. They are as variable as the conditions of the particular job itself.

Perhaps the greatest prerequisite for good straightening lies in the workman's ability to trace the source of the distortion. In the majority of cases that distortion is caused by weld contraction in the immediate vicinity of the buckle. By relieving the stress of this weld the metal will probably return to its correct position. There are a number of ways this can be accomplished. The first is by placing a strongback (or jack, or wedges, etc.) over the bulge and tighten the bolts, which in turn force the hollow toward a perfect plane. By hammering on the knuckle, usually directly over the stiffeners, the distortion caused by the pull of the weld is sometimes removed. Another method is accomplished by heating the weld, forcing the plate to a point slightly beyond its correct position and allowing the metal to cool as slowly as possible while the force of the strongback or jack is still applied. The result of this is the same as if the plate were properly braced before the original weld was made. This treatment is directly in reverse of the cause of the distortion.

The work of straightening plated structures by the use of heat involves one fundamental principle. Steel has a peculiar and somewhat unique property—that of shortening and thickening upon being heated above a red heat. It is an absolutely measurable fact that steel, when heated above a red heat, shortens; and aside from a small scaling loss, when it shortens it thickens. This phenomenon occurs whether water or a combination of air and water is used as a quencher or not. In other words, scientific measurements have proved that a piece of ship steel, after coming out of the angle-smith's furnace and left to cool at room temperature, will shorten and thicken, or, to use our expression, shrink.

In spot heating, shrinking is obtained due to the fact that when a piece is heated locally, the expansion forces set up by the expanding hot spot are resisted by the surrounding materials, and when cooling stresses set in, there is an additional pull resulting from the greater thickness brought about by the upset. Again, when a spot is heated to a cherry-red, the yield point of the steel at that area becomes very low, and the compression in the buckled panel causes a slight flow of the hot plastic metal which thickens and upsets it at this point. The cold water or, better still, water and air combined, quenches and increases the upsetting reaction to a great degree. Water is also used as a safety measure so there will be no injurious hot metal to burn a passing worker.

The actual shrinkage of a spot is very small. If the hot spot were two inches across, the shrinkage would be on the order of 0.001 in. (average). But it must be remembered that the angle which the buckled panel makes with a theoretically perfect plane is very small, and such slight angles necessitate a very slight shortening to reduce an appreciable buckle. Conversely, however, a very slight shortening will produce an appreciable buckle. That is why utmost care should be taken to prevent buckles, especially those due to weld stress.

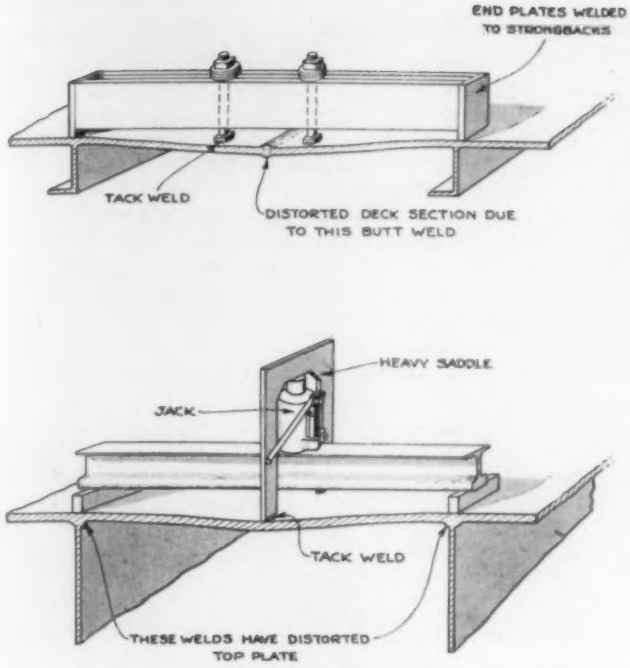
There are two ways by which the shrinking power of a spot can be greatly increased. As stated above, the compression in the buckled panel will cause the surrounding metal to flow into the hot plastic metal which thickens, and the subsequent cooling pulls the metal in. By increasing the compression artificially, a greater amount of the surrounding metal will flow into the hot plastic spot and consequently a greater shrinkage will occur.

The best method is by the use of the strongback and bolts. A bolt, or two or three according to the particular job, is welded at the center of the hollow and the strongback set up on it. When the bolt is tightened the surplus metal, forcing toward a straight plane, causes great compression and this compression, when forced against a hot spot, results in the greater shrinking power of that spot. The second way to increase the pressure upon a spot is with a flatter and sledge. By pounding around the periphery of the spot the upset is increased. Note, however, this pounding should be around the spot and not on it. The object is to increase the thickness of the spot, not to decrease it.

It is well to remember that steel heated above a red or at least 1500° F. is shortening or shrinking considerably. In other words, the amount of shrinkage obtained from blue or even dull red heats is small compared to hotter ones, because the yield point of colder heat naturally is greater.

Care must be exercised not to place heat incorrectly on badly buckled panels, especially thin plate, without the use of a stongback, otherwise it is quite probable that the condition of the plate might be aggravated instead of

* Flanger Leaderman, Richmond Shipyard No. 1.



Two Types of Strongbacks

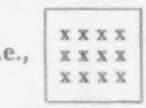
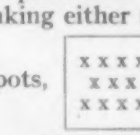
corrected. When a hot spot is placed on a curved surface, the chances are that the metal will expand into the curve to such an extent that the added metal will cause a "break" in an adjoining part, a bend that might be too strong for the pull of the cooling spot to overcome. Experience and knowledge are the shrinker's best attributes to tell whether or not a buckle is bad enough to warrant a strongback.

In some cases where shrinking or stress relieving is impracticable, a hole is blown in the center of the bulge whereupon torch, flatter and maul are used to work the excess metal toward this opening. As the stock is worked to this center, the hole becomes smaller and, fairness being obtained, it is plug welded and ground smooth. This method is used only as a last resort as it involves too much uncertainty and brawn.

The correct application of a quencher upon the hot spot is important only when the shrinker is working toward a maximum efficiency. A stream of cold, whether it be air, water or both, will cause an increase in the upsetting reaction of the metal. This is the case whether it is turned directly upon the spot or propelled around the outside of the spot and gradually worked inward.

From experiments conducted by a group of shrinkers in Richmond Shipyard No. 1, it was found that the greatest amount of pull and consequent shrinkage resulted from the following method: The water was revolved quickly *within* the periphery of the hot spot until the color had gone out. The rest of the quenching process was found to be relatively unimportant except that the spot and the surrounding area had to be completely cooled before the quench was discontinued. Imagine

three concentric circles. The smallest, *A*, has a 3-in. diameter; *B*, a 5-in. diameter; and *C*, a 7-in. diameter. Spot *A* is heated to a cherry-red approximately 1500° F. A great deal of the heat has spread to the surrounding metal, however, and *B* is about 700° F., and *C* is 300° F. If the quench is started outside *C*, or even *B*, the cooling of that area will naturally result in *C* or *B* shrinking while *A* is still redhot. This means that water directed upon *C* will cause that particular area to contract, pulling in the surrounding metal; but it is also reasonable to assume that since *A* is cherry-red and extremely resilient in this condition, a great deal of the shrinkage of spot *C* will be taken *out* of spot *A*. Since the original purpose was to cause as great an upset as possible in *A*, the shrinker is slightly decreasing his composite result. However, by cooling *A* first, he will be drawing metal from the designated areas *B* and *C*, which will give the maximum possible shrinkage.

It will be found that in spot shrinking either straight lines, i.e.,  or staggered spots,  work equally well with the latter having preferance. Spots placed in straight lines too closely together will "kick in" leaving a slight depression in the plate along that line.

If the buckle is in the center of the panel which has no immediate stiffeners around, the spots should be placed in concentric circles, starting at the edge of the buckle and working it out. Nearly all shrinking follows the same rule, that of starting at the edge and working the bump out. Because the time element is involved in most jobs, as few spots as possible are heated, otherwise it would not only take longer, but if the buckle is removed and the spots continued, it will cause unnatural stress in the end of the panel which is being worked.

Shrinking structural steel parts, such as angles, channels, I- and T-beams, involves the same principle as spot shrinking; namely, causing the steel to upset and thicken while it is hot so that when it is cooled, it has to draw from the surrounding metal. Inasmuch as nearly all shrinking on structural steel parts deals with straightening the parts when they are bent, or bending them to a correct curvature, a V or half-moon-shaped heat is used. This kind of heat results in the open end of the V having enormously greater pulling power than the closed end of the V. Naturally if the side of a beam which has the open end of the V is pulled shorter than the other side, that beam will be forced to bend. Best results with this type of heat will be gained by heating a 70°-angled V with the closed end extending to less than one-half the breadth of the beam. If the flange is on the same side as the opening of the V, then it too should be included in the heat.

The same shaped heat should also be used at the end of flat plate if there are kinks in that end. Inasmuch as the open end of the V shrinks more than the closed, the kinks which have their greatest buckle at the very edge are pulled straight; however, too many such heats at the edge of a plate will warp it. If the plate is not confined with stiffeners, it is suggested that instead of heating a solid V, spots are used in the V pattern.

Great care should be exercised by the shrinker when attempting to straighten rounded surfaces, such as bilge plates, pipes or masts. It should be remembered that the pull of a contracting spot is equal in all directions and the shrinkage of a spot on a rounded surface will force that surface toward a straight plane in *all* directions, longitudinally as well as horizontally. Therefore it is suggested that thin lines rather than spots are heated and quenched. Pipe is bent (or straightened according to the demands of the job) by running a very thin, perfectly straight, longitudinal line on the opposite side

the shrinker wishes the pipe to bend. The result of this heat will naturally make a minutely smaller circumference in the pipe, but it permits the pipe or mast to retain its perfect cylindrical shape. If the pipe were heated with a V-shaped heat as in structural steel, the pipe at the point of application would be distorted and the results unsatisfactory. Cases where a curved plate needs straightening (as on the Bilge, or D-plate) that plate should be heated and forced into place and then allowed to cool without being quenched. It will be found that better success will be obtained if the metal is forced to a point slightly beyond the desired spot as an allowance for a certain amount of spring that all metal possesses.

Inasmuch as heat travels upward, the shrinker will find that if he has a large area to cover, the fastest and best results are obtained from starting at the bottom and working upward.

Laying up angle or channel frames to the shell plating is usually a specialized job requiring a great deal of brawn as well as a knowledge of that particular work. In order that the shell plating be waterproof, the rivets must be tight, and in order to have tight rivets, the flange of the frame must be lying flat against the shell.

Practically any imperfection on the furnace slab where the structure was formed magnifies itself when that piece has to fit up to at least twenty-thousandths of an inch along the complete surface of the heel and toe of that flange, against the shell.

The fundamental in this job, is putting the heel down before the toe. This is accomplished by heating about 1 in. of the flange and 2 in. of the bosom to a cherry-red heat. A Fuller-bar is then held as nearly perpendicular to the flange as possible, and a helper hammers the Fuller till the bosom has stretched to the shell. Instances where the distance between the frame and shell is small make it possible to heat the heel of the frame and expand the metal to the shell. A strong tack is applied between the two structures which keeps them together in spite of the contraction forces which are set up by the cooling of the metal.

The toe of the frame is laid up by heating it and pounding it with a flatter and sledge. The laying up of the toe, and in some cases, the heel, can also be accomplished with a bolt and washer inserted in the frame hole and tightened outside by a co-worker while the frame is still red hot.

Radiographic Inspection Technique Applied to Special Welding Problems*

By Don M. McCutcheon†

THE application of welding in armament manufacture requires X-ray examination either as a control or in some cases, for 100% inspection. As welding is extensively used on both ferrous and non-ferrous metals and on innumerable sizes and shapes, the problems of X-ray inspection are rather large. The purpose of this paper is to describe briefly the application of X-ray inspection to some of the newer phases of war production problems.

Welded Armor Plates and Castings

The application of X-ray inspection to heavy steel castings and weldings is largely one of control. With heavy steel castings the development and control by the use of X-rays or radium has been sufficiently dealt with in the literature and will not be discussed here. The problem of the control of welding quality in armament manufacturing is at present largely regulated by rigid training of welders and spot checking of assemblies on the production line. The control of welding quality in this case becomes largely a problem of X-ray inspection. After the metallurgical specifications as to physical properties and analysis have been met the welds made on the assemblies must be sufficiently sound to prevent failure during actual service.

X-ray spot checking of completed assemblies for controlling welding quality serves primarily as a warning to the welders not to relax on quality. There are two methods used to secure complete X-ray examination of spot check jobs. The most common method appears to be the use of mobile X-ray units which can be moved into or adjacent to the production department. The alternate method of bringing the spot check job to the permanently established X-ray department offers some advantages. Equipment and building facilities in the latter case must be sufficiently large to accommodate the completed assembly. In the case of a million volt X-ray installations, the building facilities required are so large that even heavy tanks can run into the X-ray room under their own power. For partial assemblies heavy auxiliary cranes allow easy handling and positioning for X-ray examination.

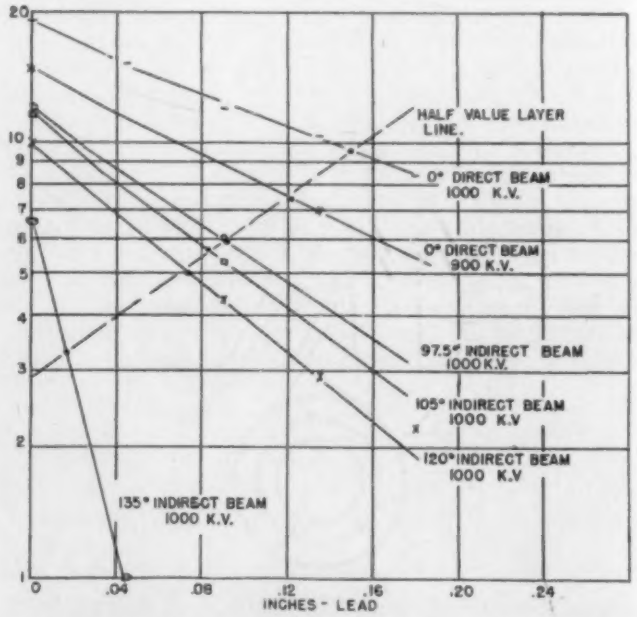

HALF VALUE LAYER LINE.
0° DIRECT BEAM 1000 K.V.
0° DIRECT BEAM 900 K.V.
97.5° INDIRECT BEAM 1000 K.V.
105° INDIRECT BEAM 1000 K.V
120° INDIRECT BEAM 1000 K.V
135° INDIRECT BEAM 1000 K.V.
INCHES - LEAD

Fig. 1—Lead Absorption Curves for a Million Volt X-Ray Unit

* Presented at Annual Meeting, A.W.S., Cleveland, Ohio, Oct. 12 to 15, 1942.

† Ford Motor Company, Dearborn, Mich.

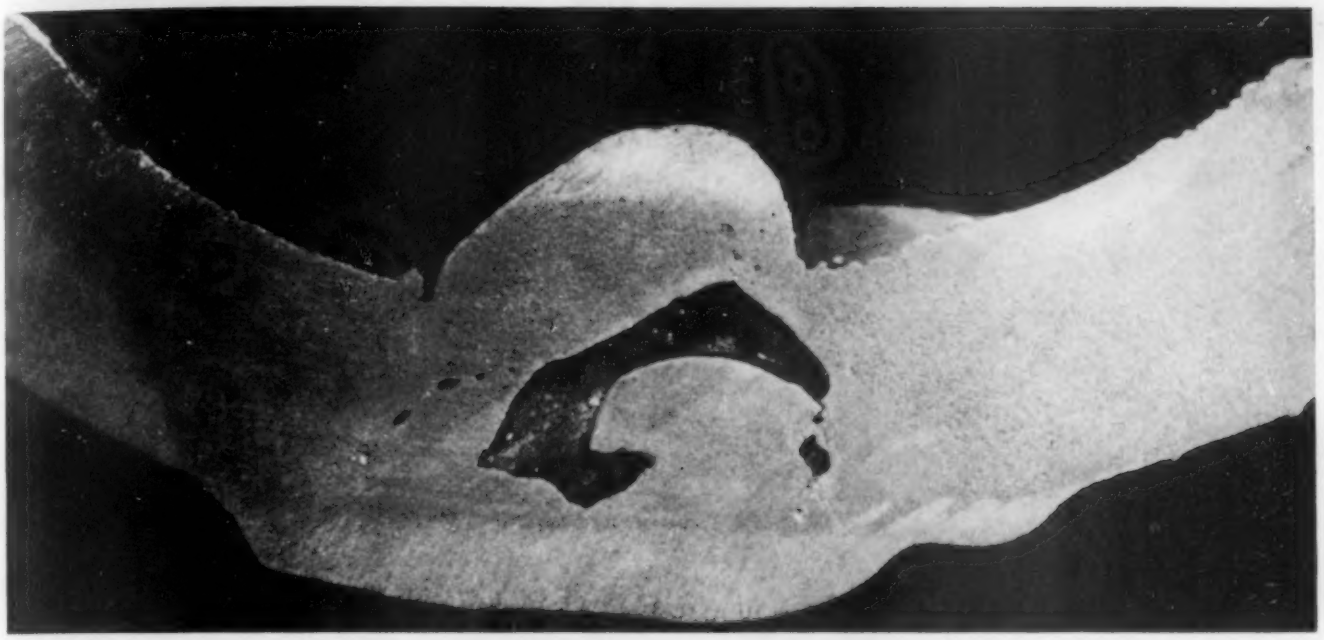


Fig. 2—Flux Inclusion in Welded Aluminum. X 5

The application of million volt radiography to armor welds offers some interesting comparisons to the lower powered X-ray units most commonly used. Welds which are considered difficult to examine by X-rays with lower powered units are relatively easy for the million volt unit. For example, the 90° welding of a heavy steel plate to a thin plate gives very poor coverage of the weld with low-voltage X-ray units. The very wide metal thickness penetration range of the million volt unit allows complete coverage of the weld at a single exposure.

Application of the million volt X-ray unit need not be limited to the heavier sections, if the proper technique is employed. Investigation of the radiation output of the million volt unit has been investigated with a view to overcoming the disadvantage of loss of film contrast and sensitivity with steel sections less than 1 in. thick.

Figure 1 shows a series of lead absorption curves taken on a million volt unit. The upper two curves are for the zero degree beam at 1000 kv. and 900 kv., respectively. The three indirect beam curves for $97^1/_2°$, 105° and 120°, respectively, show a considerable change in slope. An increase in the slope of the absorption curve indicates a higher effective wave length. The half value layer line is inversely proportional to the absorption coefficient. X-ray exposures taken with the 120° beam will show considerable increase in contrast over the 0° beam. The bottom curve for the 135° beam was taken under special conditions of diaphragming of the beam to produce a relatively large increase in the effective wave length. A heavy lead diaphragm is placed near the tube so that radiation from the principal target area is largely cut off. The radiation emitted adjacent to the principal target area is produced by lower energy electrons. A check on the quality of the beam indicates that radiation equivalent to 500 kv., filtered through 0.015 in. of lead is produced. A considerable increase in film contrast for sections below 0.5 in. can be secured by this method.

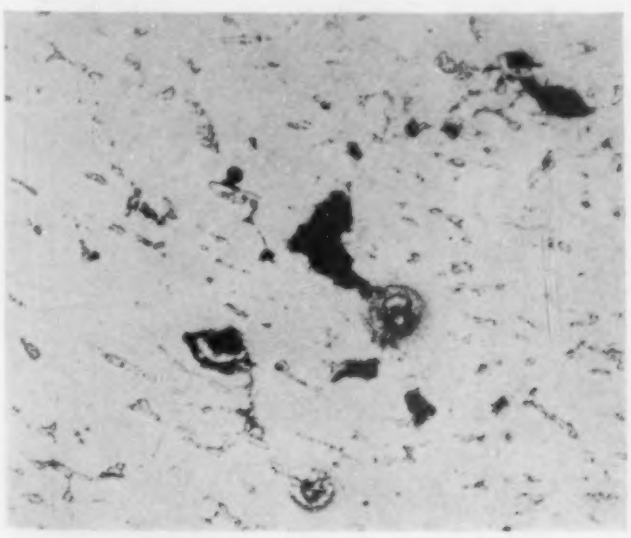


Fig. 3—Small Blowholes and Flux Inclusions. × 100

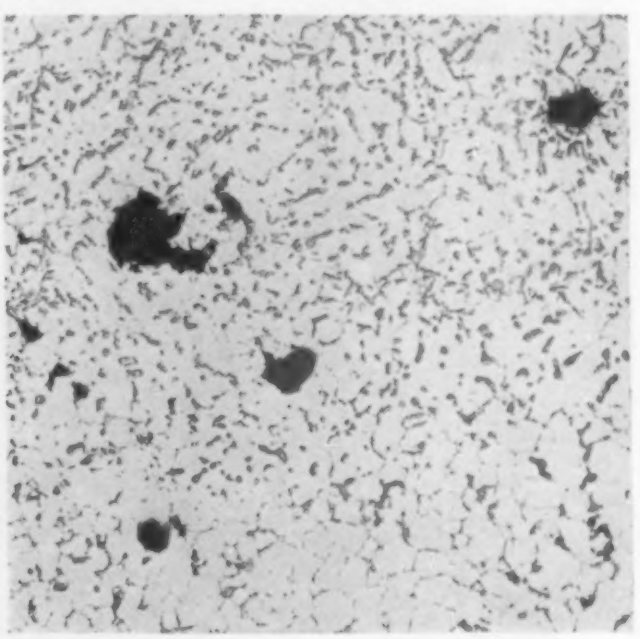


Fig. 4—Gas Porosity in the Weld Area. × 100

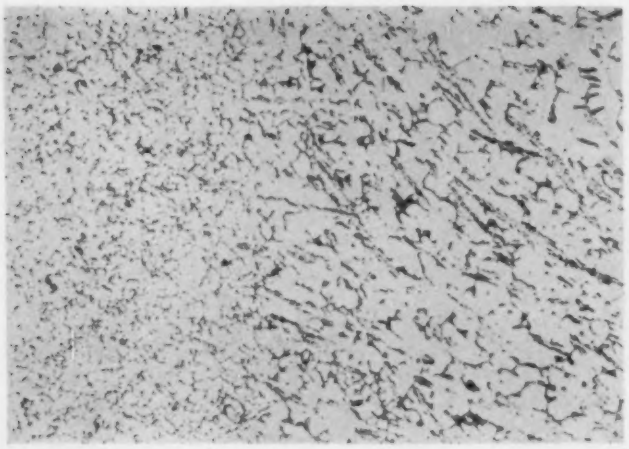


Fig. 5—Microstructure of a Good Weld. × 100

The use of the softer components of the million volt X-ray beam together with high film density, extra fine-grained films and increased developing time will produce X-ray films comparable to lower powered units on the thinner sections. Million volt X-ray application has the advantage of large tube to work distances giving increased production in the number of sections which can be X-rayed simultaneously, without excessive angular distortion of the beam. Tests have shown that with a 2-in. armor weld plate an area 8 ft. in diameter can be examined at 15-ft. tube to work distance and still obtain a crack sensitivity better than 3% at the extremity of the beam.

The Ford Motor Company's use of welding is not confined to heavy armored sections as described above, but includes the welding of the lighter metals, aluminum and magnesium. Two special applications to aluminum welding will be considered.

Repair Welding of Aircraft Aluminum Cylinder Heads

There are few light alloy castings made which are as complex and difficult to cast as aircraft aluminum cylinder heads. Scrap percentages in the foundry are usually very high for this type of casting in spite of rigid control and supervision. The defects encountered are small core shifts, insufficient metal, occasional sand inclusions and blowholes. Due to the necessary reduction of metal available for circulation in manufacturing every effort is made to salvage heads which would ordinarily be scrapped. Government permission has been obtained to repair weld cylinder heads provided adequate X-ray inspection is provided on each weld area.

Fig. 6—Poor Weld Containing Porosity, Tearing and Flux Inclusions

Fig. 7—Poor Weld Containing Excessive Porosity and Flux Inclusions

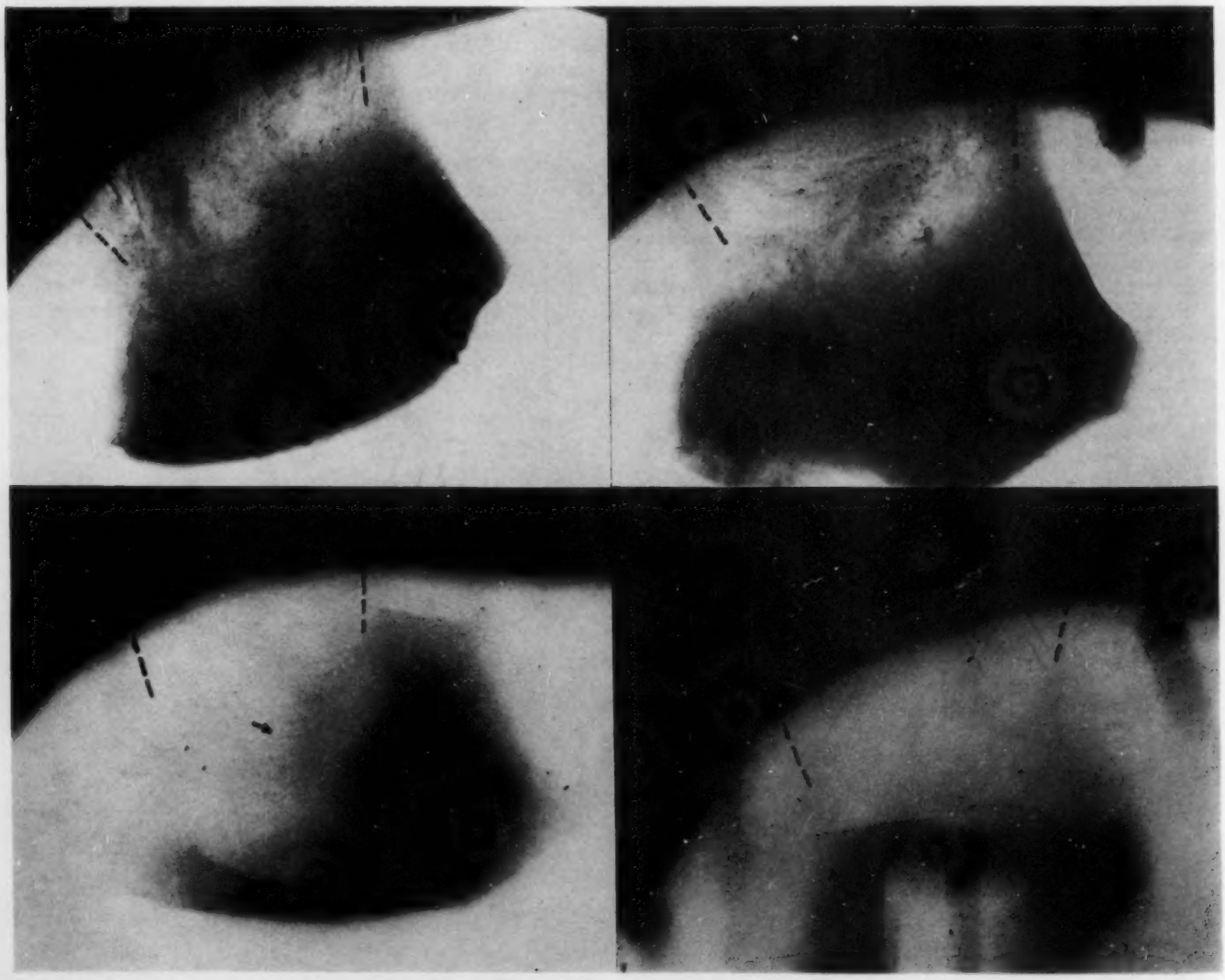


Fig. 8—Fair Weld. Flux Trapped on Successive Weld Layers

Fig. 9—Good Weld

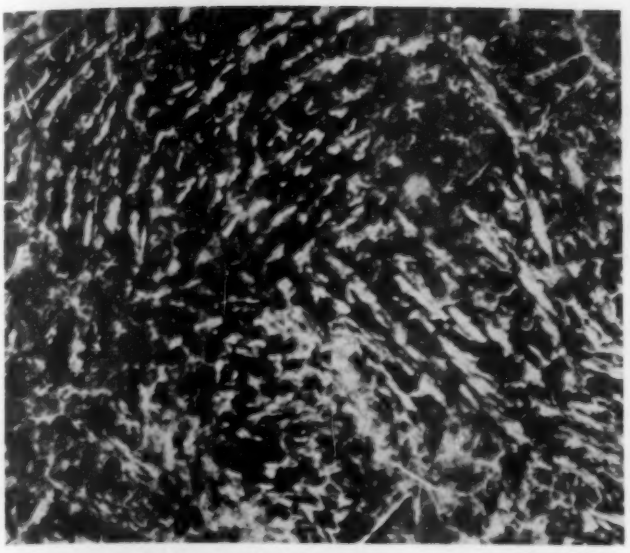


Fig. 10—Microradiograph of Thin Section of Good Weld. × 42

The X-ray examination of aircraft cylinder heads had previously been rather unsatisfactory. The technical difficulties involved were examined and a method worked out to secure good radiographs on nearly every section of the casting. A radiographic procedure has been established, based upon three requirements: the most favorable angle of the beam, low kilovoltage radiation and the use of small specially designed flexible film holders. Extensive tests were required to determine the most favorable X-ray beam angle for all sections of the cylinder head. The head is divided up into a large number of zones and photographed. The X-ray technique is marked on these prints together with the angle of the beam and the position of the film holder.

X-ray technique involving kilovoltage, exposure time and occasional use of beam filtration, was worked out both by the use of penetrameter gages and actual small drilled holes placed in the casting as artificial defects of known size. Small cassettes were made using a thin flexible vinyl plastic sheet allowing the film to be placed in contact with the metal even in difficult sections. Our experience has indicated that adequate sensitivity can be secured by X-ray examination to insure the highest quality of welding.

The limitations of any inspection process must be known and methods adopted to insure that critical defects are not allowed. X-ray examination of welding in general is limited in its ability to detect thin, uniform areas of lack of fusion. Conditions producing lack of fusion in the welding of aluminum cylinder heads are controlled by very careful training of welding operators and a frequent spot check, both by X-rays and metallographic examination of the production work of every

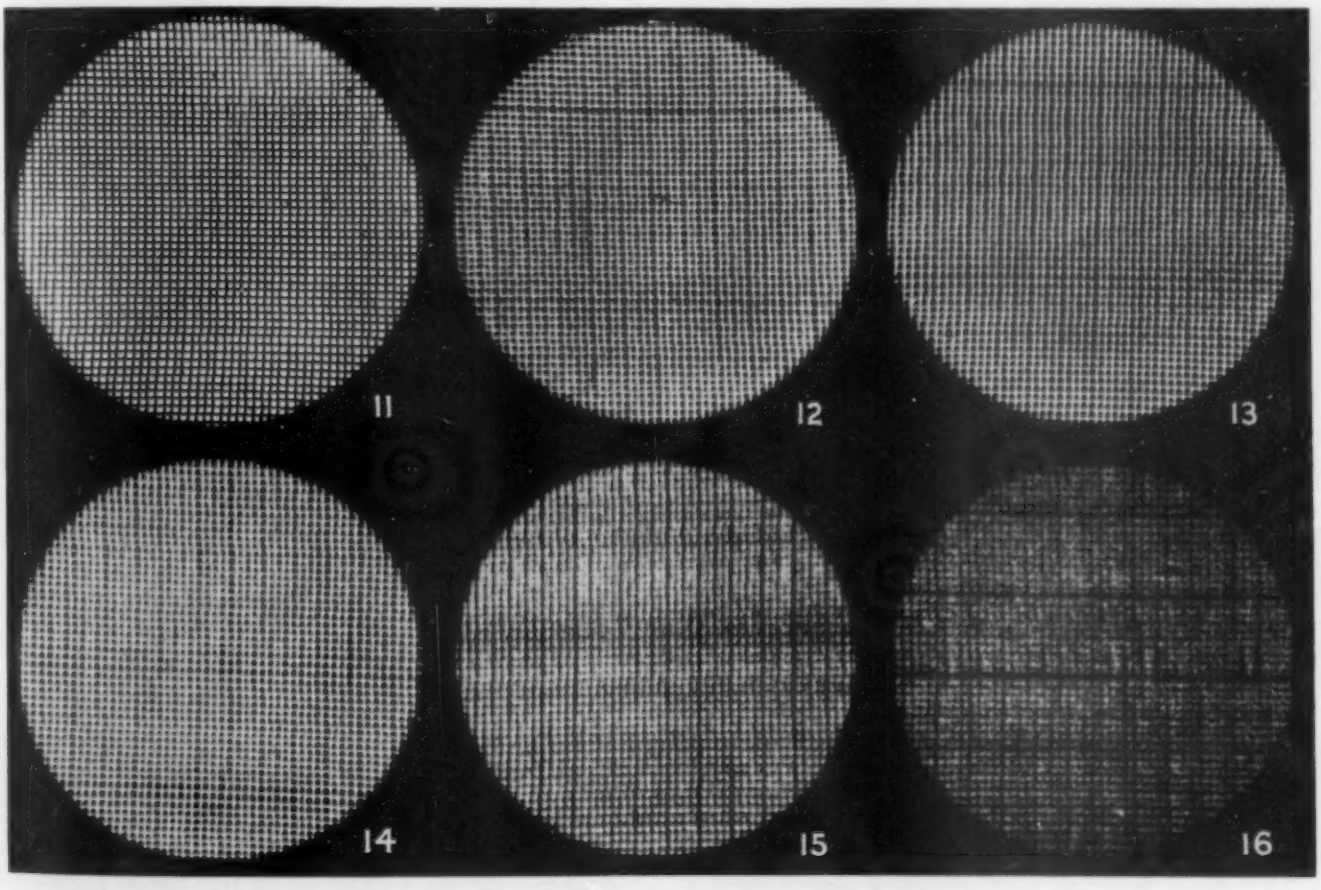


Fig. 11—Micro Photo of Wire Screen Used in Test

Fig. 12—X-Ray Image with Wire Screen Beneath a 0.015 In. Alclad Aluminum Alloy Sheet. Tube to Sample Distance of 30 Inches

Fig. 13—X-Ray Image with Wire Screen on Top of 0.015 In. Alclad Aluminum Alloy Sheet. Tube to Sample Distance of 30 Inches

Fig. 14—Wire Screen on Top of 0.030 In. Sheet. Tube to Sample Distance of 30 Inches

Fig. 15—Wire Screen Beneath 0.015 In. Sheet. Tube to Sample Distance of 7 Inches

Fig. 16—Wire Screen on Top of 0.015 In. Sheet. Tube to Sample Distance of 7 Inches

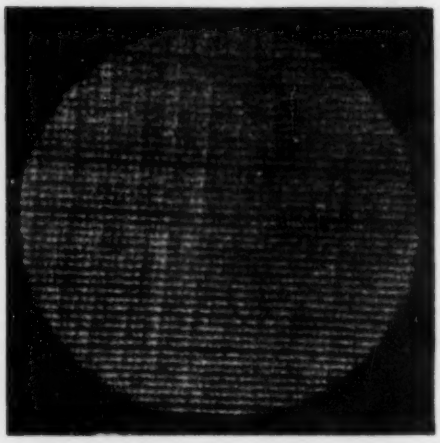


Fig. 17—Wire Screen on Top of 0.030-In. Sheet Tube to Sample Distance of 7 Inches. All × 28

welder. A careful record is kept of each welder's work and should poor welds develop this man is not allowed to continue further production welding until his technique has been corrected. In addition, all of this welder's work up to his previous spot check test, is returned for disposition by the proper authorities.

A few examples of poor welding are shown in Figs. 2, 3 and 4. Figure 5 shows the microstructure of a good weld before heat treatment. Figures 6–9 illustrate the radiographic results of good and bad welding conditions. Microradiographic technique as shown in Figure 10, is used to secure the added effect of depth which is not readily obtained by the microscopic examination of a weld area cross section.

The procedure followed in the cylinder salvage program is as follows: Defective heads are sent to the welding department for repair. Where required the heads are furnace preheated to 800° F. and welded while hot with a reducing acetylene flame. A welding rod of the same composition as the base metal, heavily coated with flux, is used on all welds. X-ray examination is made on the head according to a prescribed technique. All defects in the weld area other than a normal amount of gas porosity are cause for rejection of the weld.

Difficulty had been encountered in reaming and tapping holes on the finish machine operations due to the heavy oxide coating developed during the heating cycles. This trouble was entirely overcome by simply immersing the cylinder heads for 5 min. in a 0.5% hydrofluoric acid bath.

The application of X-ray inspection to light metals and thin sections has been a rather controversial subject, due to a lack of information available on all the factors involved. A great deal of information has emanated from the Canadian National Research Council, through Dr. L. M. Ball, particularly in a series of papers presented before the June 1942 A.S.T.M. Convention.

Effect of Distance or Focal Spot Size on Sharpness of Detail

Aluminum alloy spot welding is being used in increasing amounts by aircraft manufacturers as a means of speeding up production and improving aerodynamic efficiency by the elimination of rivets. As X-ray examination is usually specified as a control method for spot welding, the maximum amount of information which can be secured must be known. One such series of tests included the determination of the effect of lack of a point source of radiation on the sharpness and detail obtainable on the film. This is particularly true due to the tendency of inspectors to examine the small spot film images with a magnifying glass. Effects which are not apparent to straight visual examination, due to limitations in resolution, become important.

A copper screen having a wire diameter of 0.001 in., was used in a series of tests to determine the effect on resolution of the size of the focal spot of the X-ray tube *vs.* the distance of the object to the tube. A standard Eastman cardboard cassette was rebuilt using a very thin plastic sheet in place of the relatively thick cardboard front of the holder. The purpose of this change was to place the samples as close to the film as possible and to reduce the scattering of the holder to a minimum. A General Electric X-ray Corp., Model CA-5, beryllium window diffraction tube having an effective focal spot of 1.4 mm. by 1.4 mm., was used in this test. Distances of 30 in. and 7 in. of sample to target were used to measure the loss in resolution due to the size of the source of X-rays. Figures 11 to 17 show the effect of sample thickness and distance from target on the resolution at the film.

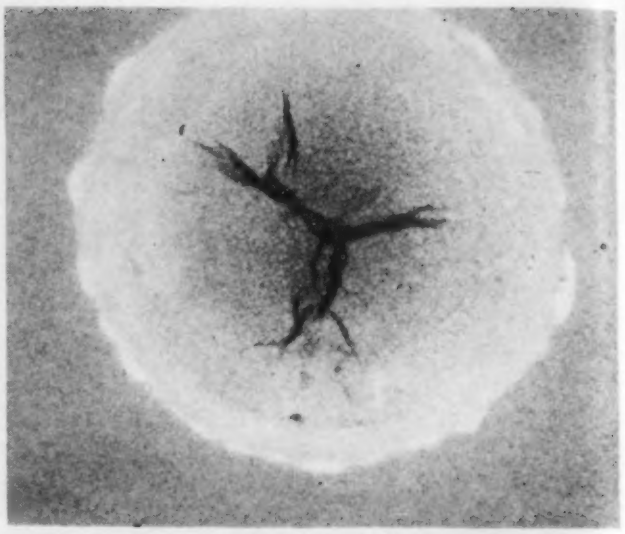


Fig. 18—Radiograph of 0.015–0.015 In. Alclad Aluminum Alloy Spot Weld

Original film shows Aluminum Splash Ring, Weld Nugget Diameter, Cast Structure Zone Containing $CuAl_2$, and Excessive Cracking Due to Overheating. × 40

Conclusions obtained from this test indicated that a fine focal spot X-ray tube is desirable, if good resolution is to be obtained on the X-ray film. Figure 18 is shown to illustrate the sharpness of detail obtainable, using the most favorable technique. Actual tests with X-ray units having focal target areas as large as 12 mm. showed that a film to target distance of 30 in. was satisfactory, if the film was to be visually examined only at an average distance of 30 in. Fine detail observed only by the aid of a magnifying glass is not registered under these conditions. The conditions of viewing and the limiting size of defect which it is desired to resolve will dictate the physical condition of the X-ray technique.

Summary

The problems involved in establishing good X-ray inspection technique on welded sections ranging from heavy armor plate to thin aluminum spot welds have been discussed. The use of million volt X-ray units on wide ranges of armor thickness requires that the proper selection of the beam angle be used to secure maximum efficiency. The X-ray examination of welds in complicated sections of aluminum castings such as aircraft cylinder heads requires that special precautions be used to insure satisfactory control of welding quality. Radiographic examination of aluminum spot welds requires the use of a technique which will insure resolution on the X-ray film of the smallest defect which is considered necessary for proper performance of the parts.

New Developments in Flame Hardening*

By Stephen Smith†

THE remarkable resistance that the Russians have put up against the great Nazi war machine may be attributed to their foresight in utilizing new mechanical and scientific developments in their armament building program. This has enabled them to build up a formidable mechanized army which has proved itself on the field of battle.

Flame hardening is one of the processes extensively utilized by the Russians. Years before the outbreak of the war, the Russian machine tool purchasing commission which had visited the United States specified flame hardening wherever it was practical on equipment they purchased here.

Following the entrance of the United States into the war, the urgent need for the immediate transformation of our peacetime industries into vast wartime production of armament found many processes ready to meet the emergency. Among these was flame hardening.

Progress in flame hardening in this country has made great strides in the past five years, with the result that the process has been firmly established as a heat-treating method and recognized as a production tool. The prompt utilization of flame hardening to the armament building program is due to its ease of adaptability to production with the minimum of time, effort, and equipment involved.

However, in spite of the great advances in flame hardening, its scope has been limited with respect to the degree of surface hardness that can be obtained on ferrous metals. Until recently it has not been possible to produce at will any desired degree of surface hardness with both of the basic methods of flame hardening. The method with which this was possible is known as the spot or unit area hardening on flat surfaces; and the spinning method when applied to round objects.

Let us examine the history of this method and note its influence on the recent developments in progressive flame hardening.

The method was first used and adopted by the railroads in 1927 for rail end hardening to reduce rail wear produced by the constant battering of the rolling stock traveling over them. This rail end hardening is a manual operation, the simplest form of flame hardening. However, by employing a definite technique and establishing a definite procedure, great proficiency and excellent results are obtained that produce substantial economics in the maintenance of way on many railroads.

An operator carries his oxyacetylene equipment on a suitable rail hand truck and travels over the rails inspecting all joints. The rail ends which are worn are built up by welding and then flame hardened. New rail ends are also hardened. In the flame hardening operation the same torch which was used for welding is employed. The operator straddles a rail at a joint and heats the rail surface above the critical temperature for a distance of three inches from the end. This temperature was at first determined by a hand pyrometer, but as the operator gained experience and became proficient, it

Fig. 1—Flame Hardening Railroad Rail Ends Manual Method Showing Heating Operation

Fig. 2—Flame Hardening Railroad Rail Ends Manual Method Showing Quenching Operation

* Presented at the Annual Meeting, A.W.S., Cleveland, Ohio, Oct. 12 to 15, 1942.

† Development Engineer, Air Reduction Sales Company, New York, N. Y.

Fig. 3—Flame Hardening Railroad Rail Ends Manual Method Showing Method of Testing Hardening and Tempering Temperature with Pyrometer

was not essential, as he could very accurately judge the temperature. After heating is completed, a water quench is applied by a suitable bucket with its bottom perforated with holes, and the rail is hardened. The extremely hard surface obtained is not suitable for the terrific impact it receives. Therefore, the surface is tempered to a lower degree of hardness. This is accomplished by slowly reheating the surface of the rail to lower the degree of hardness to 350 Brinell. The proper tempering temperature is measured by an optical pyrometer or a suitable solder is applied which melts at this temperature. This operation has been commonly accepted and automatic flame hardening machines have been developed for this work. By this method of flame hardening any desired degree of surface hardness may be obtained and the operation is applicable to relatively small areas which permit of local hardening.

For areas of extended length this method of unit area hardening is not practical. Therefore, progressive hardening is employed whereby multiple heating flames are moved progressively over the surface under treatment followed immediately by a suitable quenching stream.

In the development and application of progressive flame hardening, maximum surface hardness of the material under treatment generally was the primary requirement. This was readily obtained by the use of water as a quench for plain carbon steels and compressed air for alloy steels. This became general practice with the result that the degree of surface hardness was dependent on the type of quench medium used and on its quenching ability, that is, its rate of quench. Different mediums were employed to produce different rates of quench with the resultant different degree of surface hardness for each quench used. However, the hardness results obtained did not depart greatly from the maximum hardness obtainable on the material under treatment.

Until the recent development of the simultaneous flame hardening and tempering process by the author, no practical method had been devised to produce at will any desired degree of surface hardness on ferrous metals by the progressive method of flame hardening. Various means have been tried to produce such results without practical success. Such attempts have utilized compressed air as a quenching medium and compressed air and water to produce a mist quench. Another method tried, involved varying the distance between the quenching jets and the heating flames. The purpose of these methods being to vary the quenching rate and thereby obtain a different degree of hardness with each quenching rate. Needless to state, too many factors prevented their practical application.

The process of flame hardening and tempering involves the use of established metallurgical principles and heat-treating practice, such as heating the surface under treatment above the critical temperature, quenching with a suitable medium and reheating or tempering to the proper temperature to produce the desired degree of surface hardness. Unlike furnace hardening, wherein the three operations involved, heating, quenching and tempering are distinct and separate, each requiring separate handling, this process combines the three operations into one. All three are performed simultaneously.

It would seem at first that the application of tempering to progressive flame hardening would be obvious, but it must be borne in mind that the radically new idea in the simultaneous flame hardening and tempering process is the fact that the tempering operation is conducted at the same speed as the flame hardening operation and simultaneously with it. This idea does not conform with the accepted and established practice of furnace tempering, wherein the hardened object is slowly heated during the tempering operation.

Like all new ideas that are at first rejected as im-

Fig. 4—Flame Hardening Railroad Rail Ends Manual Method Showing Manner of Testing Surface Hardness with Portable Brinell Tester

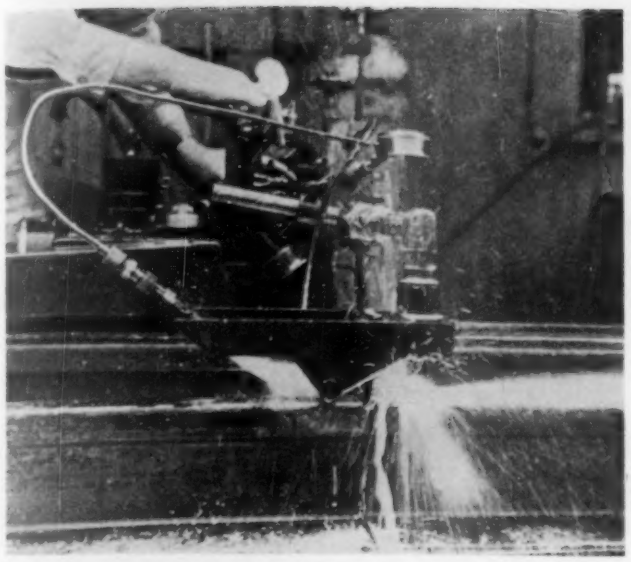


Fig. 5—Simultaneous Flame Hardening and Tempering Operation Being Conducted on the Surface of Railroad Rail—Side View

practicable and reasonable sounding arguments are advanced why they are not practicable, the main objection usually being that the idea conflicts with established and proved methods in current practice; the process was developed and proved in the field. However, its development was not unattended by difficulties.

The simultaneous flame hardening and tempering process embodies the use of a standard multiflame oxyacetylene flame hardening tip with a quenching jet incorporated following the flames. A soft multiflame heating tip is employed at a definite distance to the rear of the quenching stream for the tempering operation. This tip is attached to the flame hardening tip by a suitable fixture thus making a unit assembly. The unit is moved progressively over the surface to be treated at a definite rate of speed for a desired depth of hardness. The quenching jets following the heating flames cool the surface producing hardness. By applying a definite type of quench under sufficient volume and pressure a definite degree of hardness may be obtained. The tempering tip following behind the quenching stream heats the hardened area to any temperature desired, thereby drawing the temper of the hardened surface and producing a lower degree of hardness.

The intensity of the tempering flame may be varied at will to increase or decrease its heat. This is accomplished by varying the pressure of gas used. This provides a positive means of controlling the surface temperature following the flame hardening operation. The temperature to which the hardened area is raised will determine the amount of the tempering that will result and thereby the final degree of surface hardness. It has been found necessary to employ a baffle plate behind the quench to reduce excessive splashing of the quenching stream toward the tempering flame. This assures uniform tempering.

All phases of the process may be controlled to produce duplicate results. The heating operation is controlled by the unvarying temperature of the oxyacetylene flame to produce a uniform hardening temperature; the hardness is controlled by the quenching medium which may be regulated as to temperature, pressure and volume and finally the heating operation for tempering is also controlled by the unvarying temperature of the oxyacetylene flame. With all phases of the operation under positive control uniform results are assured and the process may be used in production, to produce large quantities of identically hardened parts. A number of such production installations are now in operation.

The need for conserving the vital alloy steels for our armament requirements and the substitution of plain carbon steels has greatly aided in increasing the development and advancement of all rapid surface hardening processes. By applying these processes to the available steels and other ferrous materials, a combination of physical properties are obtained which equal, and in many cases surpass, the properties of the original alloy steel part. One application where the simultaneous flame hardening and tempering process is being used on plain carbon steel to replace an alloy steel is on railroad frogs. Difficulty is being experienced by the railroads in obtaining manganese steel frogs to replace worn manganese frogs now in service. Furnace heat-treated carbon steel frogs have been used, but the cost of these is relatively high and existing heat-treating equipment inadequate. Replacement of manganese frogs with carbon steel flame hardened frogs is now under way. As it is not necessary to harden the whole frog, flame hardening is an effective means of producing the wear

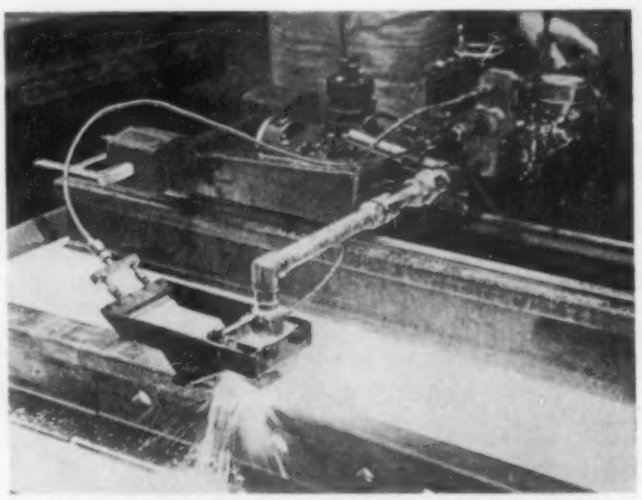


Fig. 6—Simultaneous Flame Hardening and Tempering Operation on the Surface of Railroad Rail—Plan View

resisting properties only where needed. A number of flame hardened frogs are now being tested in the field under heavy service conditions.

The surface hardness requirements on frog rails is similar to that of rail ends, being a medium hardness, ranging from 350 to 400 Brinell to withstand the high impact loads and repeated stresses. The simultaneous flame hardening and tempering process is the most effective means of obtaining this hardness quickly, economically and with the least equipment.

It is too early at this stage of development to list all the possible applications of the process. These will reveal themselves as the process is adopted to each new application. It would seem that its most fertile field of application will be to produce definite surface hardness on parts subjected to heavy impact and fatigue stresses, such as axles, torque shafts, propeller shafts and oil well drill stems.

Simultaneous flame hardening and tempering bridges a definite gap in the existing field of flame hardening, and the adoption of this new development will undoubtedly broaden the scope of the entire flame hardening process.

Designing for Production Welding

By H. A. Oldenkamp*

PROPER design and its effect on production cannot be overemphasized, especially during our all-out war program.

Oftentimes the welding department of a plant will work valiantly on methods for faster production by using proper jigs and fixtures, higher currents, larger electrodes, positioners, etc. These efforts are fine and should be encouraged. However, in addition, the designer should become highly sensitive to welding costs and speeds. The necessity of actually calculating the sizes and lengths of welds to do certain jobs should be brought "home" to him. Specifying too much weld on a drawing results in wasted material and unnecessary labor.

Welded design offers unlimited possibilities to the designer for cutting cost over cast and other types of constructions. However, the initial welded design, while it may cost less than the cast part, should be studied for additional possibilities of cost reduction. An example of how the amount of welding was lowered 28% by going over the design is shown in the accompanying Figs. 1, 2 and 3.

The diagrams show the development of a motor-mounting base on a turret lathe. Figure 1 is the original cast-iron base; Fig. 2, the initial welded design; and Fig. 3, the final welded base after redesigning.

The amount of welding, as already pointed out, was reduced 28% merely by changing the type of bracing. Solid gusset plate braces are shown in Fig. 2. These braces were changed to $^1/_2$- x 2-in. braces, thus eliminating much of the welding. The new base was found to be amply strong and, also, the warpage was held to a minimum.

Incidentally, at the same time this change was made, simple welding fixtures were built to facilitate the welding. The parts, *A*1, *B*1, *C*1 and *D*1 (Fig. 3) are welded as a subassembly after first being tack welded in a small fixture. Likewise, *A*2, *B*2 and *C*2 are welded into a subassembly. The subassemblies are then placed on the $^5/_8$-in. thick plate and tack welded in place with a third simple locating fixture, and finally securely welded to the plate. This system not only provides a quick method for locating the parts, but the subassemblies are easy to handle and can be welded by a man sitting at a bench. In the old method, where all the parts were first tack welded on the $^5/_8$-in. thick plate, it was necessary for the plate to be lifted into various positions in order to make all the joints accessible, necessitating the use of two men on the job, or one man and a crane. With the

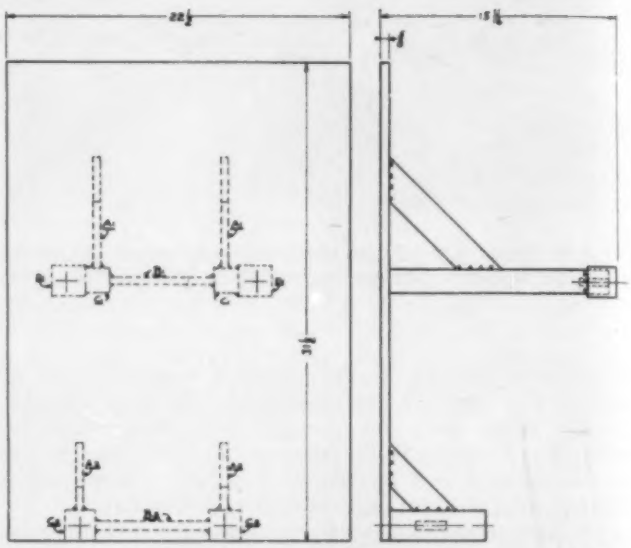


Fig. 3—Revised Welded Steel Base

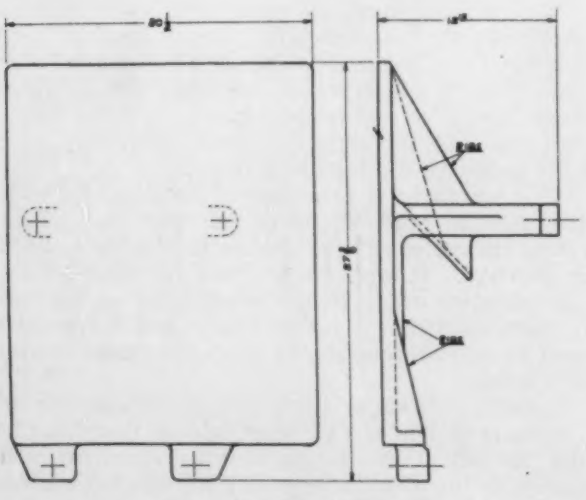


Fig. 1—Cast Iron Motor Base

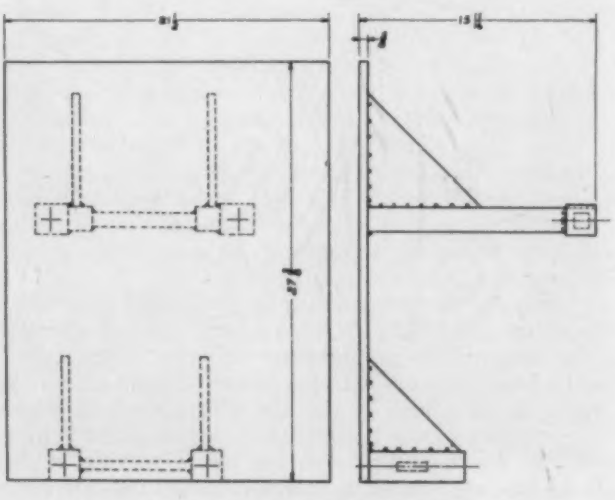
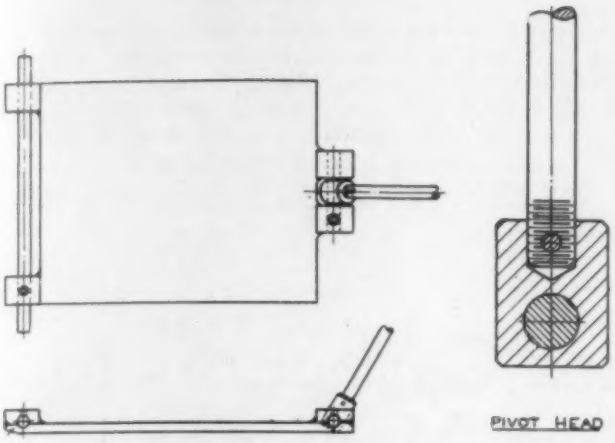


Fig. 2—Original Welded Steel Base

* Welding Consultant, The Warner & Swasey Co., Cleveland, Ohio.

Fig. 4—Obsolete Design



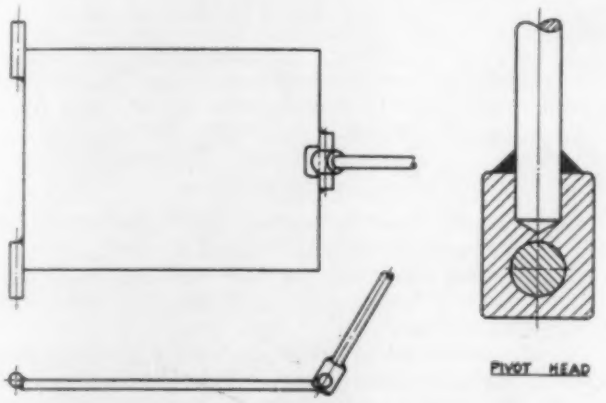


Fig. 5—Improved Design

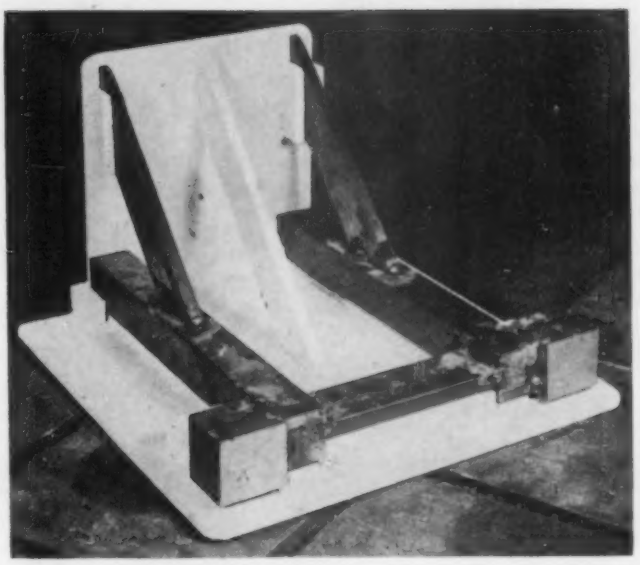


Fig. 6—This Photograph Shows the Welding Fixture with the Subassembly Mounted in Place

new subassembly method, it is only necessary to move the whole assembly after it is completely welded.

Altering the design and using welding fixtures reduced the welding time, including setup, from 1 hr. each to 35 min.

Figures 4 and 5 show two methods of building a motor-swing base. This example shows how welding can be used to reduce machining and assembly time.

An excessive amount of cutting and welding was necessary on the original design, as can be seen in Fig. 4. There is no machining necessary for the base shown in

Fig. 7—This Photograph Shows the Operator Sitting Down, Completing the Welding on the Subassembly

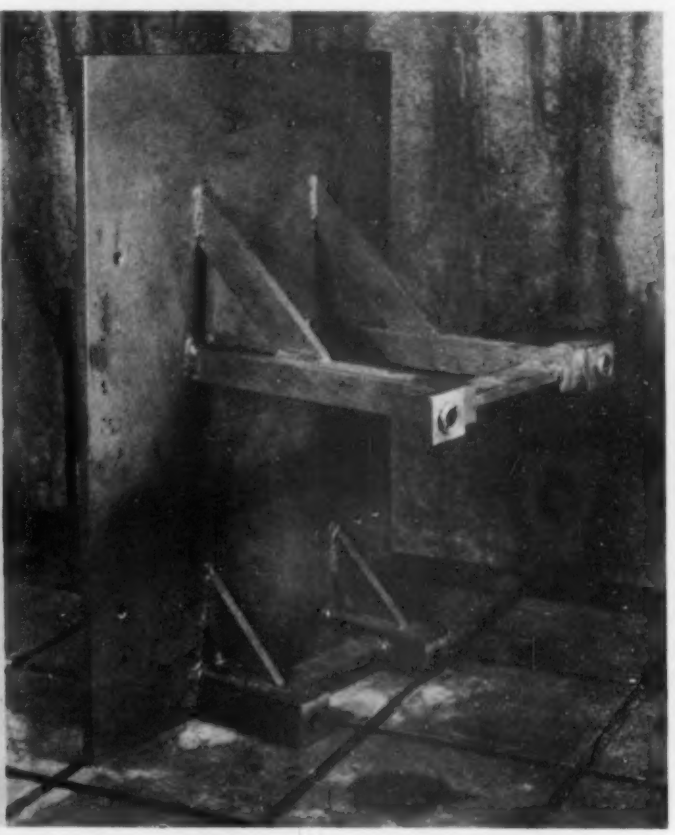


Fig. 8—The Completed Motor-Mounting Base, Showing the Subassemblies Welded Into Position

Fig. 5, while previous design requires the drilling and reaming of a number of holes, tapping for set screws and a milling operation.

The pivot head was previously screwed into place and locked with a pin. With the new construction, the pivot head is welded in place. The pivot pin is also welded into position, making a permanent assembly. This assembly was felt to be satisfactory because the parts never have to be replaced.

Although both swing bases are of welded construction, the one shown in Fig. 5 costs 25% less than the previous design.

Design is probably the most important factor in the cost and time of welding. Because of the fact that there are relatively few reliable handbook rules and tables on this subject, a designer must be thoroughly familiar with actual welding procedures and methods of welding, in addition to having a fair knowledge of the functions of the machine for which he may be designing various parts.

Application of Series Capacitors to Resistance Welding Machines

By R. M. Partington*

THE technical details of this subject have been adequately described in a previous publication.[1] The following presents a method of determining the series capacitor requirements and discusses some points that have come up in connection with its application.

Resistance welding machines generally impose a large intermittent single-phase load at low power factor on the distribution system. The power factor (watts/(volts × amperes)) is usually between 0.25 and 0.50 which is low power factor compared to that of other modern electrical apparatus.

The source of the unusually low power factor lies primarily in the physical configuration necessary in the machine parts carrying the welding current from the welding transformer to the electrodes. That is, it is necessary to separate the two arms carrying the welding current to the electrodes in order to insert the work between them. In general, the greater the separation between these arms and the longer they are, the greater will be the ratio of reactance to resistance and consequently the lower the power factor will be. Also the material being welded influences the power factor. In other words the total kilovolt-ampere demand of the welder is made up of a large reactive kilovolt-ampere component, and a resistive kilowatt component. This kilowatt component supplies the power to make the weld and supplies the losses of the machine.

Frequently this type of load presents such difficulties to the power supplier that he finds it necessary to apply restrictions to its use in order to minimize the interference with other customers. These restrictions have often dictated the use of auxiliary equipment[2] and facilities of such magnitude that the welding process could not be economically justified. In those cases where restrictive measures do not apply to welder users, one or more of the following conditions may occur which make power-factor corrective means desirable.

1. Interference between two or more welders on the same line.
2. Flickering of lights.
3. Interference with other electrical apparatus on the same line.
4. Tripping of circuit breakers due to the high current surges required by the welders.

By connecting a capacitor of proper rating in series with the primary of the welding transformer, the feeder need supply only the kilowatts. This reduction in kilovolt-ampere demand will simplify the supply problem and bring about the following beneficial results:

1. Complete removal or lessening of the restrictions imposed by the power supplier.
2. Welding machines may be installed on existing feeders too small to supply the usual low power-factor machines.
3. Heavier welds are possible from a given feeder.
4. Minimized interference with other welders and apparatus on the same feeder.
5. Reduction of light flicker to a level not generally objectionable.
6. More welding machines may be used on the same feeder, providing all are equipped with series capacitors.
7. Smaller feeder and power supply equipment are needed for new welders.
8. The necessity of running a separate feeder for a welder can probably be avoided.
9. Special low impedance power supply transformers are not necessary.
10. Long throat machines will have practically the same kilowatt demand as short throat machines.

Method of Connecting Series Capacitor

Figures 1, 2 and 3 show three ways in which the series capacitor may be connected into the welder circuit.

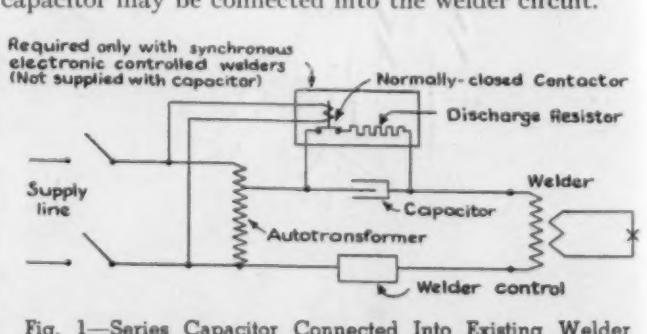


Fig. 1—Series Capacitor Connected Into Existing Welder Circuit Between Autotransformer and Welder

The welder voltage is equal to the line voltage. This circuit cannot be used with electronic control where the secondary voltage of the autotransformer is less than approximately 230 volts because of the control tube requirements.

* Capacitor Engineering Dept., General Electric Company.

1. Levoy, L. H., Jr., "Power Factor Correction of Resistance Welding Machines by Series Capacitors," *A.I.E.E. Transactions*, **59**, 1002–09 (1940).
2. Crago, H. R., "Demand Improvement for Resistance Welding Loads," THE WELDING JOURNAL, **20** (11), 797–99 (1941).

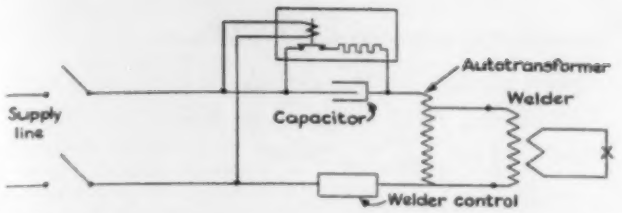


Fig. 2—Series Capacitor Connected Into Existing Welder Circuit, on the Line Side of the Autotransformer

The welder voltage equals the line voltage. This arrangement removes the limitation of the connections shown in Fig. 1.

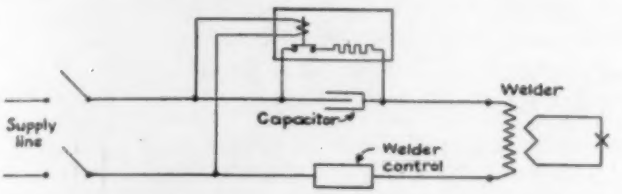


Fig. 3—Series Capacitor Connected Into Circuit of New Welding Machine Where the Line Voltage, Capacitor Voltage and Welder Voltage Have Been Coordinated for the Application

Figure 1 applies to all existing welding machines where the welder voltage is approximately the same as the supply line voltage. This circuit has one limitation, namely, that it cannot be used with electronic control when the secondary voltage of the autotransformer is less than approximately 230 volts, because of the control tube requirements. To illustrate its operation, assume the welder was operating on a 440-volt line at 50% power factor and making a line current of 600 amp. After the capacitor and autotransformer are installed the line current will be reduced to 300 amp. at unity power factor, the secondary voltage of the autotransformer will be 220 volts, the welder current will be 600 amp. at 440 volts and the capacitor 381 volts.

Figure 2 applies to existing welding machines and removes the limitation of Fig. 1. Furthermore Fig. 2 allows the use of higher voltage capacitor units, which are usually more economical, although this advantage may be more than offset by changes that may be necessary in the existing control equipment. To illustrate its operation assume the welder was operating on a 440-volt line at 50% power factor and taking a line current of 600 amp. After the capacitor and autotransformer are installed the line current will be reduced to 300 amp. at unity power factor, the primary voltage of the autotransformer will be 880 volts, the capacitor voltage 762 volts and the welder current will be 600 amp. at 440 volts.

Figure 3 applies to new welding machines where the line voltage, capacitor voltage and welder voltage have been coordinated for the application. This circuit would also apply to existing welding machines when the welding transformer primary has been rewound for operation with a series capacitor. To illustrate its operation the line voltage will be 440 volts at unity power factor and the line current 300 amp., the capacitor voltage 762 volts and the welder voltage 880 volts at 50% power factor.

In the above three circuits it should be noted that a discharge resistor is connected across the series capacitor through a normally closed contactor, energized from the load side of the supply line switch. With synchronous control this arrangement is necessary, so that when the welder is operating the resistor is disconnected thus permitting a direct current charge to be maintained on the capacitor between successive welds. When the line switch is opened the contactor will close permitting the resistor to discharge the capacitor. With non-synchronous control the resistor could be permanently connected across the capacitor. This discharge resistor conforms with the National Electric Code requirements on draining the stored energy from capacitors.

Data Necessary for Capacitor Selection

To estimate the size of a series capacitor to improve the power factor of a resistance welding machine to approximately unity, the following data should be obtained. These data may be supplied by the welding machine manufacturer where new machines are anticipated. However, it may represent actual readings taken during the operation of an existing machine.

1. Kilovolt-amperes (volts × amperes ÷ 1000) and power factor (watts ÷ volts × amperes) under maximum working conditions.
2. Kilovolt-amperes and power factor with the electrodes directly short circuited, in order to determine maximum current and maximum voltage across the capacitor.
3. Line voltage and frequency.
4. Type of control, that is, mechanical contactor, synchronous or non-synchronous electronic control.
5. Duty cycle (cycles on, cycles off, pulsation per weld and welds per minute).

Methods of Obtaining the Required Data

The above data may be obtained by any one of several methods depending upon available instruments and facilities.

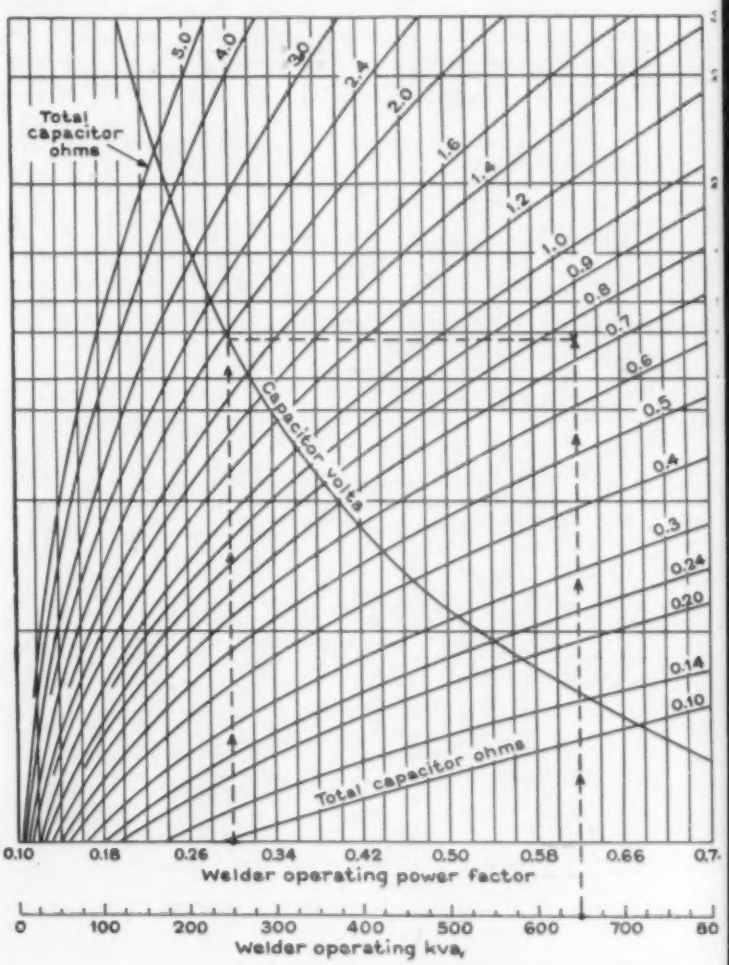


Fig. 4—230-Volt 60-Cycle Line. For Welders with Electronic Control and Duty Cycles of 44% or Lower

One of the most reliable methods is to read the volts, amperes and watts input into the high-voltage side of the welding transformer. That is, the voltmeter and wattmeter should be connected on the load side of the welder control and not on the line side. Usually these readings cannot be taken while the welder is operating, without using stop-pointer meters. However, ordinary indicating meters can be used if the line voltage is reduced by an autotransformer so that the current can be maintained long enough to get a reading on the meters. The welder control should be shorted out so as to make certain that the input to the welding transformer is full wave. In taking data the maximum working condition should be duplicated. If it is possible to bring the welding electrodes directly together during operation, data should be obtained on that condition which will give the greatest line current.

Another reliable method of obtaining the necessary data is with a two-element oscillograph. One element should record the voltage directly across the high-voltage side of the welding transformer and the other element should record the current input into the high-voltage winding. The product of the voltage and current will indicate the kilovolt-amperes and their separation on the horizontal axis will indicate the power factor. This method can be used while making regular welds. However, the data should be taken with full wave operation.

Calculation of Required Series Capacitor

The following formula indicates a method of calculating both the number and rating of capacitor units required to correct the power factor of a resistance welding machine to unity.

For electronic control the effective line volts = v. − 15 (tube drop) (*a*)

For mechanical contactor the effective line volts = v. (*a*)

Working Condition:

Line demand in kw. at unity power factor = kva. × P.F. (P.F. $\cos\theta_1$) (*b*)

$$\text{Line current at unity power factor} = \frac{\text{kw. } (b) \times 1000}{\text{eff. line volts } (a)} \quad (c)$$

$$\text{Welder primary volts} = \frac{\text{eff. line volts } (a)}{\cos\theta_1} \quad (d)$$

Capacitor volts = welder prim. volts (*d*) × $\sin\theta_1$ (*e*)

$$\text{Capacitor ohms} = \frac{\text{cap. volts } (e)}{\text{line current } (c)} \quad (f)$$

Short-Circuit Condition:

$$\text{Welder impedance (ohms)} = \frac{\text{welder prim. volts } (d)^2}{\text{kva.} \times 1000} \quad (g)$$

Welder resistance (ohms) = welder imp. (*g*) × $\cos\theta_2$ (*h*)

Welder reactance (ohms) = welder imp. (*g*) × $\sin\theta_2$ (*k*)

Net reactance (ohms) = cap. ohms (*f*) − welder reactance (*k*) (*l*)

$$\text{Net impedance (ohms)} = \sqrt{(h)^2 + (L)^2} \quad (m)$$

$$\text{Line current} = \frac{\text{eff. line volts } (a)}{\text{net impedance } (m)} \quad (n)$$

Welder prim. volts = line current (*n*) × welder imp. (*g*) (*p*)

$$\text{Welder kva.} = \frac{\text{welder volts } (p) \times \text{line current } (n)}{1000} \quad (s)$$

Capacitor volts = line current (*n*) × cap. ohms (*f*) (*u*)

The following example will illustrate the use of the above formula.

Example 1

Given Data: An electronic-controlled welder having a working condition of 650 kva. at 0.3 power factor and a short-circuit condition of 750 kva. at 0.26 power factor. Welder to operate on a 230-volt, 60-cycle line at 30% duty cycle. Correction to unity power factor.

Working Condition:

Effective line volts = 230 − 15 = 215

Line demand in kw. at unity P.F. = 650 × 0.3 = 195 kw.

$$\text{Line current at unity P.F.} = \frac{195 \times 100}{215} = 906 \text{ amp.}$$

$$\text{Welder prim. volts} = \frac{215}{0.3} = 717 \text{ volts}$$

Capacitor volts = 717 × 0.954 = 684 volts

$$\text{Capacitor ohms} = \frac{684}{906} = 0.755 \text{ ohm}$$

Short-Circuit Condition:

$$\text{Welder impedance} = \frac{717^2}{750 \times 1000} = 0.685 \text{ ohm}$$

Welder resistance = 0.685 × 0.26 = 0.178 ohm

Welder reactance = 0.685 × 0.966 = 0.661 ohm

Net reactance = 0.755 − 0.661 = 0.094 ohm

$$\text{Net impedance} = \sqrt{(0.178)^2 + (0.094)^2} = 0.201 \text{ ohm}$$

$$\text{Line current} = \frac{215}{0.201} = 1070 \text{ amp.}$$

Welder prim. volts = 1070 × 0.685 = 733 volts

$$\text{Welder kva.} = \frac{733 \times 1070}{1000} = 785 \text{ kva.}$$

Capacitor volts = 1070 × 0.755 = 808 volts

Selection of Capacitor Equipment

The capacitor unit ratings that have been assigned for this type of capacitor application are given in Table 1. From the above calculations it was determined that a 0.755-ohm series capacitor was necessary to improve the given working condition to unity power factor. Also the capacitor volts was 684 and the duty cycle 30%. Since the given duty cycle is less than 44%, refer to the column headed Maximum Working Volts and choose a unit satisfactory for 684 volts. This is the 14-ohm unit with a maximum working voltage of 690.

$$\text{Number of units required} = \frac{14}{0.755} \text{ or 19 units}$$

However, this unit has a maximum permissible voltage of 758 volts whereas the calculations indicate a capacitor voltage of 808 volts for the short-circuit condition. Consequently 24 units of 17.7 ohms each, would be required if the units are self protecting, or (19) 14-ohm units with an overvoltage protective equipment to limit their voltage on short circuit.

Curves for Quick Estimating

To quickly estimate the series capacitor requirements, to correct to unity power factor, curve sheets Figs. 4, 5 and 6 have been drawn up for welder line voltages of 230, 460 and 575 volts at 60 cycles. These curves apply for duty cycles of 44% or less, for connections shown in Figs. 2 and 3, and for electronic control (with 15 volts assumed as tube voltage drop) so that the effective line voltages are 215, 445 and 560 volts.

Example 2

Given Data: A welder having a working condition of approximately 650 kva at approximately 0.3 power factor to operate on a 230-volt 60-cycle line at approximately 30% duty cycle.

Solution: On Fig. 4 follow a vertical line from 0.3 power factor to the intersection with curve marked capacitor volts. Then project horizontally until this line intersects a vertical line from 650 kva. At this point a total series capacitor ohms of 0.75 can be read. Now for convenience, it will be noted that the ohmic values for the individual series capacitor units are indicated in the right-hand margin and the solid horizontal lines indicate the maximum allowable operating voltage at 44% duty cycle or less, for each capacitor unit. In the present example the point lies between the 12-ohm and 14-ohm capacitor, therefore, the 14-ohm unit should be used, since the capacitor voltage exceeds the maximum working volts for the 12-ohm unit.

$$\text{Number of units required} = \frac{14}{0.75} \text{ or 19 units}$$

Example 3

Given Data: A welder having a working condition of approximately 100 kva. at 0.38 power factor to operate on a 230-volt 60-cycle line at approximately 10% duty cycle.

Solution: On Fig. 4 we find that the total series capacitor ohms required are 3.0 and the capacitor ohms per unit are 10.5 so that the minimum number of units required is 3.5. In this case, since the required number of units is small and a whole number of units is not indicated, we try the next higher rated unit, namely, 12 ohms and arrive at an even figure of 4 units.

The above examples indicate how easily the size of series capacitor equipment can be estimated without making any measurements whatever providing a reasonably good estimate can be made of the working kilovolt-amperes and power factor. These estimates should, of course, include an overvoltage protective equipment. While the above will serve for estimating purposes, in no case should approximate data be used if an installation is being planned. In all cases of planned installations accurate data should be taken as called for under the heading Data Necessary for Capacitor Selection or obtained from the welding machine manufacturer.

Effect of Errors in Data Necessary for Capacitor Selection

The effect of errors in determining the maximum working conditions of a welder can be easily illustrated through referring to Figs. 4, 5 and 6.

From these curves it is apparent that the voltage rating of the capacitor units is determined by the welder operating power factor. For example on Fig. 4 with power factors of 0.26, 0.30 or 0.42, the capacitor ohms per unit are 22, 14 or 8.3, which corresponds to capacitor unit voltage ratings of 575, 460 or 330 volts. Consequently it is very important that the operating power factor of the welder be accurately determined in order to establish the voltage rating of the capacitor units.

After the power factor has been established the number of capacitor units (to be connected in parallel) are determined by the welder operating kilovolt-amperes. For example on Fig. 4 with a power factor of 0.30 and kva. of 350, 450 or 700 the total series capacitor ohms are 1.4, 1.1 or 0.7 which requires 10, 13 or 20 units.

The line voltage also determines the voltage rating of the capacitor units. For example on Figs. 4 and 5 with

Table 1—Series Capacitor Units for Resistance Welders

Continuous 60-Cycle Rating Volts	Ohms	μf	Maximum* Allowable Working Volts	Maximum† Permissible Volts
230	7.05	375	345	380
330	8.3	320	495	545
400	10.5	250	600	660
425	12.0	220	638	700
460	14.0	190	690	758
485	15.5	170	728	800
515	17.7	150	783	850
575	22.0	120	863	948
660	29.4	90	990	1090
705	33.1	80	1058	1164
750	38.0	70	1125	1238
815	44.2	60	1223	1345
895	53.0	50	1343	1478
1000	66.2	40	1500	1650
1150	88.3	30	1725	1900
1320	118	22.5	1980	2180
1630	177	15	2445	2690
2000	265	10	3000	3300
2300	353	7.5	3450	3800

* Maximum operating voltage for duty cycles up to 44%.
† Maximum permissible voltage with welding electrodes shorted. For duty cycles greater than 44%:

$$\text{max. working voltage} = \frac{\text{rated voltage}}{\text{duty cycle}}$$

Maximum *on* period = 1 minute continuous.

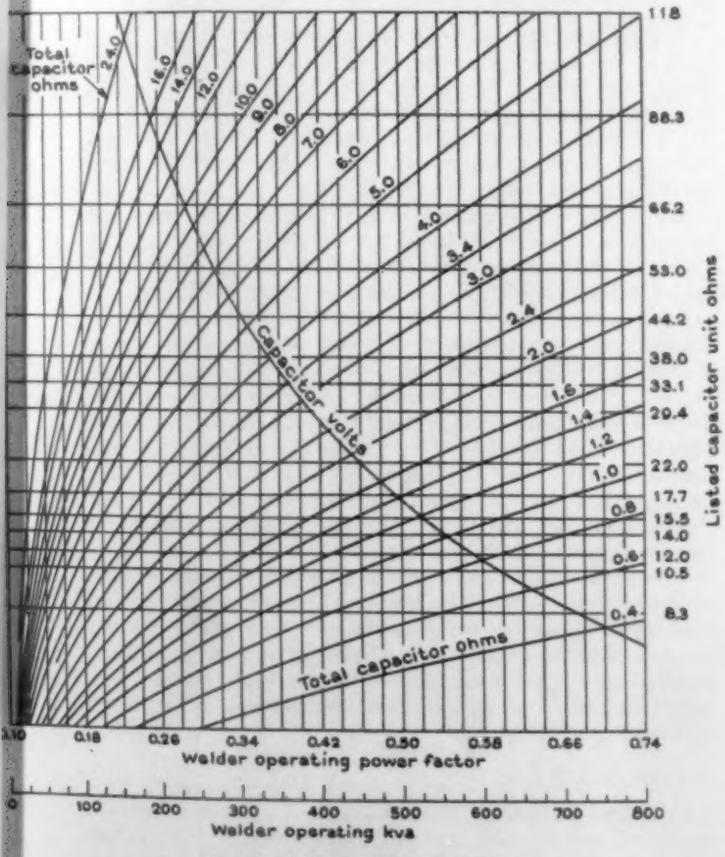


Fig. 5—460-Volt 60-Cycle Line

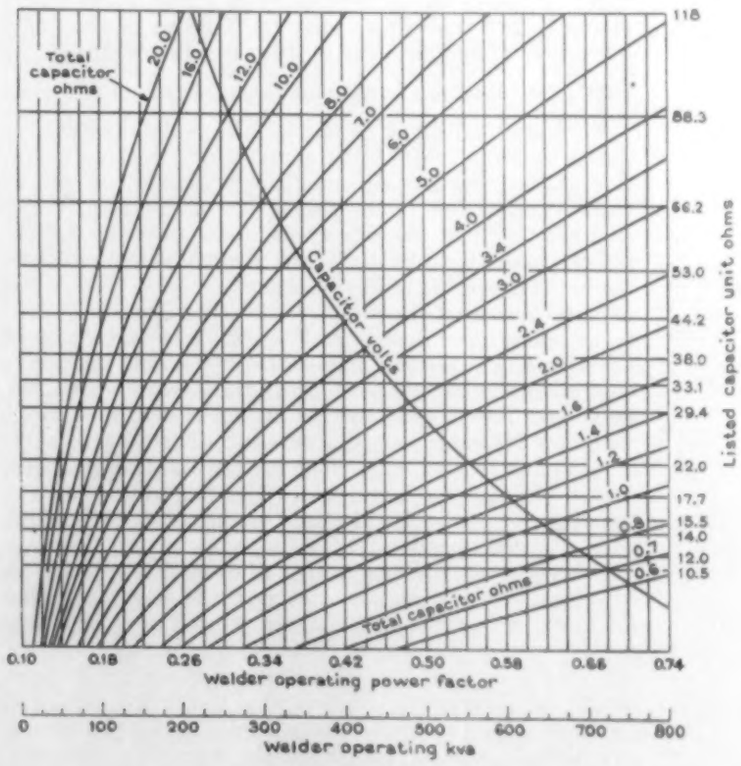


Fig. 6—575-Volt 60-Cycle Line

Table 2—Correcting to Less Than Unity Power Factor

Corrected line P.F.	Welder kva.	Welder P.F.	Ohms per Unit	Number of Units
100%	650	30%	14.0	19
90% lag	650	30%	10.5	20
100%	650	27%	17.7	19
90% lag	650	27%	10.5	16

a power factor of 0.30 the capacitor ohms per unit are 14 and 66.2 which corresponds to capacitor unit voltage ratings of 460 and 1000 volts.

Correcting to Less Than Unity Power Factor

The primary purpose in correcting power factor of resistance welding machines is to reduce their demand on the system. Their demand is reduced to a minimum when their power factor is improved to unity. Consequently the incentive for correcting to less than unity power factor would be a desire to reduce the number capacitor units required. The number of capacitor units required, from those listed in Table 1, bears no fixed relation to the line power factor. Correcting to less than unity power factor may require more or less units than are needed to correct to unity power factor, depending upon the specific problem.

For example, consider two synchronous controlled welders, both operating at 650 kva. on a 230-volt, 60-cycle line at 44% duty cycle. One welder operates at 30% power factor and the other at 27% power factor. Table 2 shows the number of units required to correct these welders to unity and 90% lagging power factor. The 27% power factor welder requires less units to correct to 90% power factor than it does to correct it to unity power factor. The 30% power-factor welder requires more units to correct to 90% power factor than it does to correct it to unity power factor.

This variation is due to the capacitor voltage coming between two of the ratings listed in Table 1 (the higher rating is always used), so that the number of units may be greater or less than the unity power factor correction.

Welder Performance with a Series Capacitor

The series capacitor should be designed to correct the power factor to unity for the maximum working condition so that any subsequent changes in the load will be to decrease rather than increase it. Consequently any changes made in welding transformer taps, throat position, material welded or heat control setting will be made to reduce the welding current.

A series capacitor equipped welder designed for maximum operation will operate satisfactorily when any of the above changes are made. If any one of the above changes are made while the other three remain fixed, the line power factor will decrease and there will be a corresponding decrease in the line current. For all conditions of tap changes, material changes, heat control changes, throat changes or accidental short circuiting of the welding electrodes, the demand on the line will be less with a series capacitor.

In those cases where a variety of work is to be done on a welder where it may be necessary to weld the same thickness of material with different throat positions, taps should be provided on the welding transformer. When the throat is increased the welding transformer ratio should be decreased. In this way the series capacitor can reduce the line current to a minimum for practically any throat position providing the necessary taps are available on the welding transformer. The operation is practically the same as other welders without series capacitors.

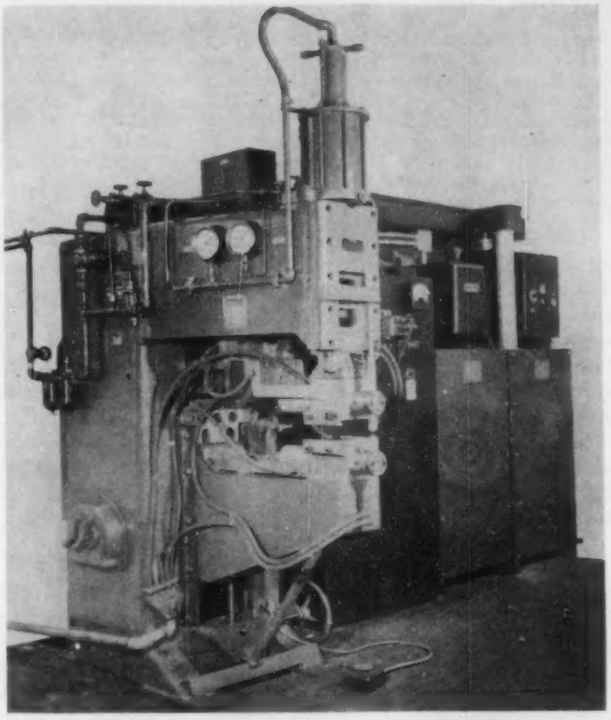


Fig. 7—190-Kva. Spot Welder Equipped with Thyratron Phase Control, Sequence Control and Series Capacitor for Power-Factor Improvement. Capacitors Are in the Two Containers at the Right

Series Capacitors for Welders Located on the End of Long Distribution Lines

Frequently the reason for applying corrective measures in this case is due to the lights flickering when the welder operates. This is due to the drop in voltage in the line caused by its resistance and reactance. Applying a series capacitor to the offending welder to correct its power factor to unity will reduce the current demand on the line and reduce the light flicker.

However, this improvement, in some cases, may not be sufficient to reduce the flicker below the objectionable level. For these special cases a capacitor can be inserted in series with the transmission line to neutralize the reactance of the line. This type of capacitor provides instantaneous compensation for the voltage drop in the line for all loads on the line. The action of the transmission line series capacitor is similar to that of an induction regulator except that it is instantaneous in its operation and therefore compensates for suddenly impressed loads such as a welder. The compensation may be such that the voltage at the receiving end of the line will be equal to, less than or greater than the voltage at the sending end of the line.

The application of one or the other of these two types of series capacitors depends upon the particular problem. The series capacitor for power-factor correction reduces line current demand and thereby improves voltage regulation. The transmission line series capacitor has very little effect on line current demand but it improves voltage regulation.

Typical Installation

In order to illustrate the flexibility of a series capacitor equipped welder, the installation shown in Fig. 7 has been selected. This spot welder is used for fabricating a

large variety of materials of different thicknesses in which the throat opening may vary for different jobs.

The welder is equipped with synchronous control, sequence control, a pointer-stop ammeter, an air circuit breaker and taps on the welding transformer. The transformer taps are connected to a selector switch which has a high heat and a low heat position.

Maximum welding current is obtained on the high-transformer tap with 100% heat setting on the control panel. For this condition the welding machine demand is approximately 300 kva. and the line demand is approximately 150 kw. at unity power factor. Lower welding currents are obtained through reducing the heat control while connected to either the high or low transformer tap. The material welded varies from two pieces of $^1/_4$-in. steel down to two pieces of $^1/_{32}$-in. steel.

For the lower welding currents the line power factor may decrease to 92%. This decrease in line power factor apparently has no effect on the operation of the welder. The demand on the line is less for all conditions than it would be without the series capacitor.

This machine has been operated on a large variety of work. The quality of welds are very consistent so that scrap losses are practically negligible.

X-ray Method *vs.* Guided Bend Method of Testing Electric Arc Welders*

By Carlton G. Lutts,† Stuart D. Herbein‡ and Lloyd W. Pote§

Introduction

NEARLY all manual arc welders employed in ship construction are required to pass the qualification test outlined in Fig. 1. The test, in one of its forms, consists of making butt welds in $^3/_8$-in. medium steel plate, one member of each joint being galvanized. Two specimens are then machined out of the welded plate and subjected to a guided bend test.

With the advent of X-ray examination to determine the quality of welds and its ever-increasing application, it was desired to investigate the possibility of adopting this method of examination as an alternate to the guided bend test required for the welders' qualification tests, Fig. 1.

Purpose of Test

1. To determine whether the X-ray method of examining qualification plates is practicable as an alternate to the guided bend test.
2. To determine degree of correlation existing between the X-ray and guided bend-test methods of examination.
3. To set up a proposed X-ray standard of minimum acceptance for use as an alternate to the guided bend test.

Method and Results of Test

X-ray examinations and guided bend tests were made on 630 consecutive welders' qualification plates. These plates were prepared by 210 new welders attempting to pass Welders' Qualification Test shown by Fig. 1, using $^5/_{32}$-in. grade EA electrodes. Each plate was X-rayed after removal of the reinforcement and backing strap. Bend specimens were then machined out and subjected to the guided bend test.

Before attempting to correlate the resulting 630 X-ographs with bend test results, it was first necessary to classify the X-ographs between themselves with respect to welding quality. This was done by examining the entire lot of films and then selecting a group of 10 to represent the entire range of welding quality observed. The ten representative films were arranged in order of fault importance, proceeding from X-ograph No. 1 representing perfection, in approximately equal increments, to X-ograph No. 10 which was the worst condition. Figure 2 is a photograph of the 10 standards. All remaining films were compared with the ten standards and were assigned ratings 1 to 10 accordingly. Figure 3 gives the results of the X-ograph classification, showing the number of X-ographs (630 total) falling in each rating. Figure 3 also gives results of the bend tests in which the plates were rated "pass" or "fail."

Of the total of 630 plates, there were 350 plates which passed the bend test. These 350 plates were grouped as regards to their X-ray ratings. Figure 4 shows that 14 plates had rating No. 1, 65 had rating No. 2, etc. It can be noted that the bulk of the plates passing the bend test lie in the X-ray rating range 2 to 5.

Similarly, the 280 plates which failed the bend were grouped according to their X-ray ratings with results given in Fig. 5. It can be noted that the bulk of specimens failing in the bend test are concentrated in the X-ray rating range 6 to 8.

The two curves, Figs. 4 and 5, are presented on the same graph, Fig. 6, for joint examination. From this examination, it appeared that standard No. 5 should prove the most accurate of the ten in correctly predicting bend results, and on this basis would be the most suitable minimum acceptance standard.

The suitability of X-ograph standard No. 5 as a minimum acceptance standard is further demonstrated in Table 1 below. This table was derived from the data of Fig. 6 and shows the per cent of bend results correctly predicted by each of the 10 X-ograph standards when applied to:

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* Presented at the Annual Meeting, A.W.S., Cleveland, Ohio, Oct. 12 to 15, 1942. Opinions or assertions contained in this paper are the private views of the authors and are not to be construed as official or reflecting the views of the Navy Dept. or Naval Service at large.

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1. The 350 plates passing the bend test.
2. The 280 plates failing the bend test.
3. The total of 630 plates (pass and fail).

Table 1

X-ograph Standard No.	Per Cent of Bend Results Correctly Predicted		
	350 Plates Passing Bend	280 Plates Failing Bend	Total (630 Plates)
1	4.5	100	48.5
2	23	98	55
3	44.5	95	67
4	66	90	76
5	81	80	81
6	93.2	53	75
7	96.5	30	67
8	99	16	62
9	100	5.5	58
10	100	0	55

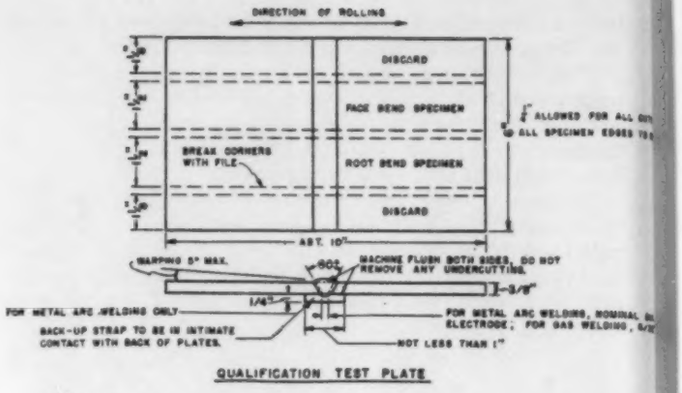
It can be noted that if X-ray standard No. 1, the most rigid of the ten standards, were used as the minimum acceptance standard, all of the 280 plates which actually failed in the bend test would have been rejected, but that only 4.5% of the 350 plates which passed the bend would have been considered acceptable. The total accuracy of prediction of standard No. 1 thus amounted to only 48.5%. Standard No. 5 showed the greatest total accuracy of prediction, 81%, and showed about this same accuracy in predicting each of the two groups of bend results, namely, the 280 bend failures and the 350 bend "passes." Standard No. 5 was therefore chosen as the X-ray standard of minimum acceptance on the basis that it most nearly simulated the guided bend test.

The accuracy of prediction obtained using standard No. 5, 81% means that 19% of the bend results were incorrectly predicted. Referring to Fig. 6, it can be seen that this 19% discrepancy between the two methods was divided about equally between the two groups of bend results. Thus a 9% portion was acceptable according to standard No. 5, but failed in the bend test while a 10% portion was rejected according to standard No. 5, but passed the bend test.

The 19% discrepancy between the two methods may in part be due to the fact that both methods do not measure exactly the same quality. The guided bend test particularly measured the quality of the metal near the surface of the bend-test bar at which location the greatest stretch occurs. The X-ray test assigns equal importance to both the condition at the surface and the condition in the interior of the specimen. Thus defects revealed by X-ray, which are located at depths, may not cause failure of the specimen in the bend test. Accordingly, the 10% portion of the plates actually passing the bend test may have had internal defects with sound and good quality metal at the surface.

Regarding the 9% portion of the plates which appeared to pass according to the X-ray standards, but which actually failed in the bend test, this situation might be explained by considering the manner in which the plates were X-rayed. The direction of radiation was normal to the surface of the weld in all instances, thus striking the planes of fusion at an angle of 30°. There was then the possibility of any incomplete fusion along these planes escaping detection. An alternate method of X-raying plates, wherein the radiation is directed parallel to the planes of fusion, is thus suggested but is not herein reported.

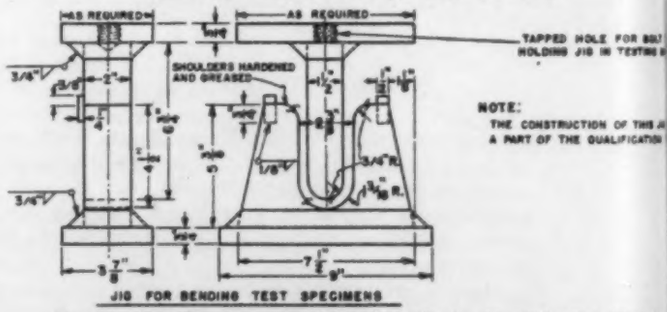
Comparing the two methods of inspecting welds, on a time basis, it appears that the X-ray method, as herein reported for single exposures taken normal to the specimen will require fewer man-hours than the guided bend



QUALIFICATION TEST PLATE

NOTES:

1. Plate material shall be steel of low (0.31% maximum carbon content.
2. For metal arc welders:
   (a) One test plate shall be welded in vertical and one te plate in the overhead position. If no overhea welding is to be done, one test plate shall be welde in the vertical position.
   (b) 3/16 In. diameter covered steel electrodes shall be used
   (c) Temperature of previously deposited weld meta shall not exceed 212° F. at time of deposition o subsequent layer.
3. For gas welders:
   (a) 3/16 In. diameter welding rods shall be used.
   (b) One test plate shall be welded in vertical and ov test plate in the overhead position. If no over head welding is to be done, one test plate shall b welded in the vertical position if flat welding onl is to be done, but one test plate is to be made an that in the flat position.
4. Welding shall be done from one side only.
5. Joints made in the vertical position by metal arc weldin shall be welded upward.
6. No peening shall be done.
7. No preheating shall be done.
8. No stress relieving shall be done.
9. Specimens to be machined transverse to weld.
10. Test specimens shall be bent to full capacity of jig.
11. Face bend specimens to be bent with face of weld in tension.
12. Root bend specimens to be bent with root of weld in tension.
13. Any specimen in which a crack or opening exists befor bending, or results from the bending, exceeding 1/8 in measured in any direction, shall be rejected.



JIG FOR BENDING TEST SPECIMENS

Fig. 1—Test Specimens and Bending Jig for Qualification Test for Welders Except Aircraft Gas Welders

method. This is derived from a time analysis on 12 plates as shown below:

Table 2

Operation	Time, Hr. Bend Method	X-ray Method
Remove backing strap	2	2
Remove reinforcement	2	2
Sawing into strips	3	
Shape strips to size	2 1/4	
Miscellaneous grinding, etc.	3/4	
Bend testing	3/4	
X-ray developing and rating		2
Total time (12 plates)	10 3/4	6
Time: Man hours per plate	0.90	0.50

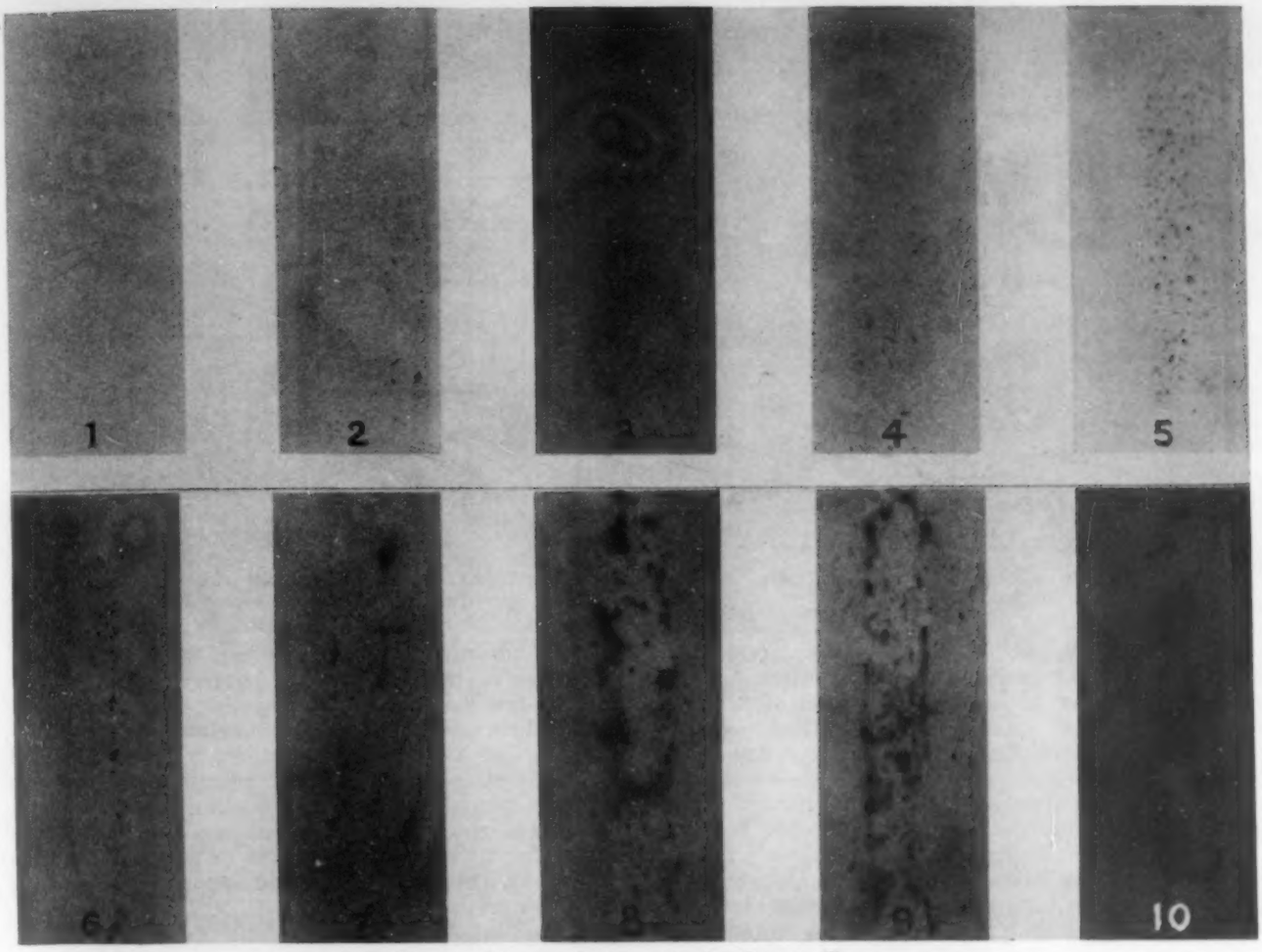


Fig. 2—X-ographs Standard—One to Ten

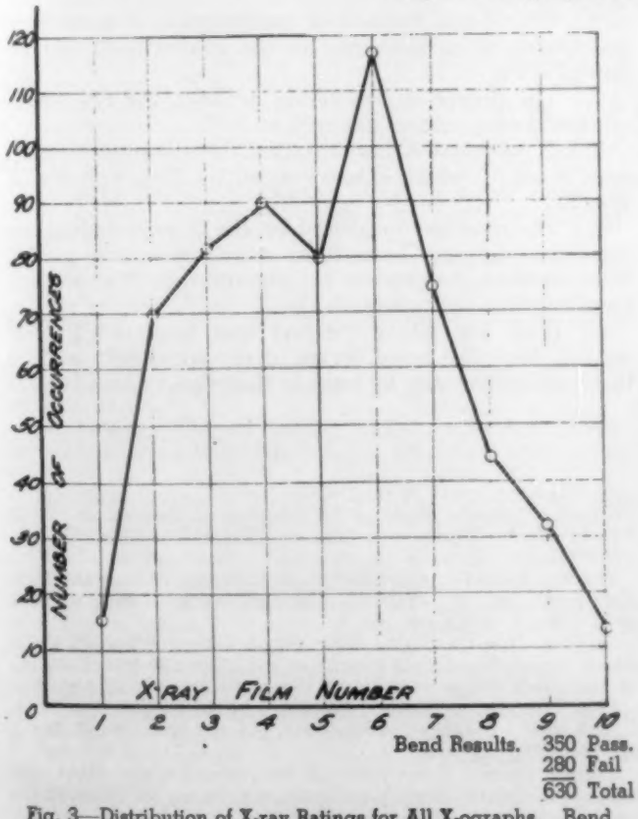


Fig. 3—Distribution of X-ray Ratings for All X-ographs. Bend Results Included

Supplementary Tests

It might be concluded from the subject test that the X-ray method examining welders' qualification plates was only 81% as reliable as the guided bend method, since it predicted 81% of the bend results correctly. This, however, is based on the assumption that the guided

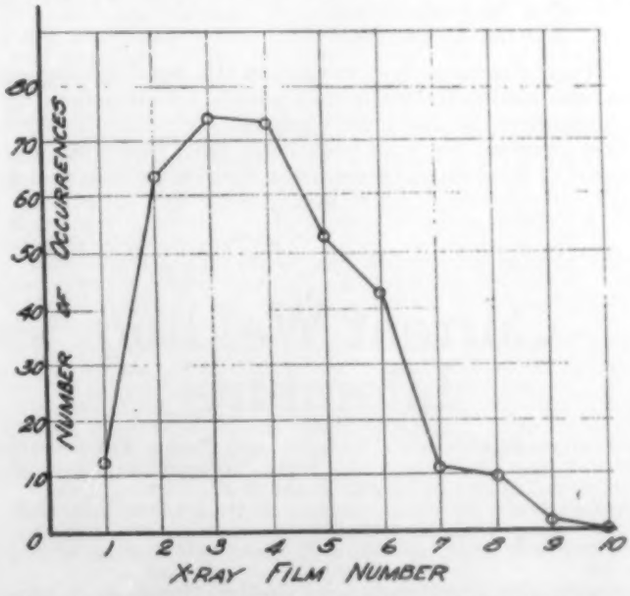


Fig. 4—Distribution of X-ray Ratings for Specimens Passing the Bend Test

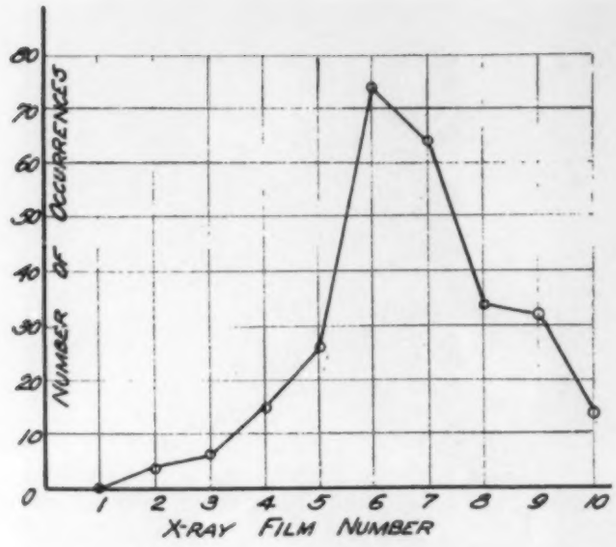


Fig. 5—Distribution of X-ray Ratings for Specimens Failing the Bend Test

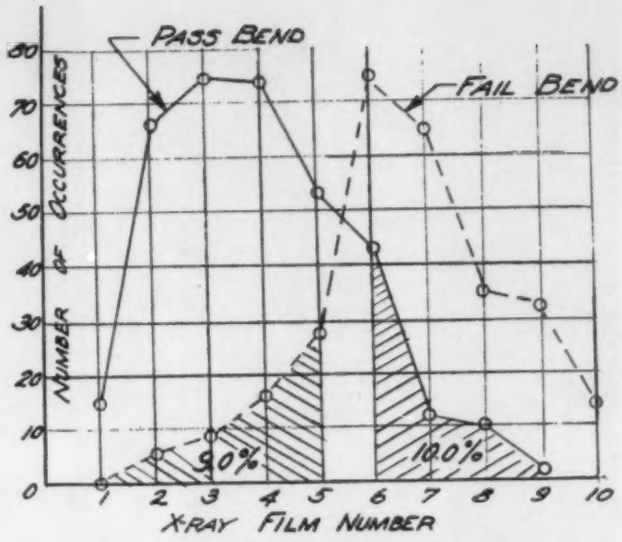


Fig. 6—Distribution of X-ray Ratings for Specimens Both Passing and Failing the Bend Test

bend method is the ideal standard of acceptance. This is not necessarily true since the X-ray method might equally well be set up as the ideal standard to which other methods are referred. In this latter case, the guided bend test predicted only 81% of the X-ray results correctly.

In choosing the standard to be used, whether guided bend or X-ray, consideration would probably be given to the degree of reproducibility and conversely the degree of uncertainty existing in the two methods. The following described tests indicate that neither method is without fault, and that both methods have about the same degree of reproducibility.

Three independent observers were assigned to rerate bend specimens and the corresponding X-ographs of 305 of the 630 plates originally studied. These 305 plates covered about the same range of welding quality as the 630 plates, as a whole. The purpose was to determine to what degree the three observers could check one another in order to determine the reliability of their stated result:

1. For the guided bend.
2. For the X-ographs.

Three observers first examined the bend specimens and recorded individually and privately their opinion as to whether the specimen "passed" or "failed." The three opinions for each plate were then compared and extent of agreement between the three observers noted. It was found that all three observers agreed in 81% of the instances, thus indicating a degree of uncertainty of 19% for the bend method.

The three same observers then examined the corresponding 305 X-ographs with respect to X-ray standard No. 5. A plate was rated "pass" when its X-ograph was considered equal or superior to standard No. 5 and "fail" when its X-ograph was considered inferior to this standard. The three observers agreed in 80.5% of the instances, indicating a degree of uncertainty of 19.5% for the X-ray method.

Conclusions

1. The X-ray method of qualification is considered practicable as an alternate for the guided bend test required in Fig. 1.
2. The degree of correlation between the two methods for testing welders amounts to 81%.
3. A proposed X-ray standard for minimum acceptance is set up which is represented by X-ograph No. 5, Fig. 2.
4. The qualities measured by the X-ray method are somewhat different from those measured by the guided bend method, accounting largely for the 19% discrepancy between the two methods.
5. Both the X-ray method and the guided bend method have the same degree of reproducibility and on this basis either may be used as the primary standard.

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(*Continued on page 43*)

THE AMERICAN WELDING SOCIETY

ACTIVITIES — RELATED EVENTS

TECHNICAL APPOINTMENTS

Shortly after his elevation to the position of Technical Secretary, Mr. L. M. Dalcher obtained a leave of absence from the Society to join the U. S. Army Ordnance. He is receiving his basic training at Aberdeen, Md., and shortly thereafter is expected to receive officer's training.

Mr. W. Spraragen, Editor of THE WELDING JOURNAL and Executive Secretay, Welding Research Council, filled the gap temporarily. At its meeting on December 10th, the Executive Committee acting on the recommendations of the Committee on Outline of Work, appointed Mr. C. W. Obert in a consulting capacity with the title of "Acting Technical Secretary." Working under him on a full-time basis, the Committee selected Mr. Simon H. Greenberg, with the title of "Assistant Technical Secretary." Mr. Greenberg is a graduate of the Civil Engineering Department of Brooklyn Polytechnic Institute. He has had several years' experience in welding inspection, qualification and design with the Brooklyn Navy Yard, the Philadelphia Navy Yard and a structural company.

SECOND ANNUAL SCIENCE TALENT SEARCH OPENS

Twenty-five thousand high school principals and teachers have been invited to take part in a nation-wide search among the country's 1,650,000 high school seniors for the 40 most talented young scientists of that age in America. The 40 are to be singled out for special honors and opportunities including attendance at a five-day Science Talent Institute at Washington next February, and up to $14,000 in scholarships.

The invitation to teachers has been sent to the nation's high schools by Science Clubs of America, an organization fostered by Science Service. The Science Talent Search, second to be held, is made financially possible by the Westinghouse Electric & Manufacturing Co., which will award Westinghouse Science Scholarships to at least 10, and possibly 40, of the young scientists of the future.

Objectives of Search

Objectives of the Science Talent Search are:

1. To discover and foster the education of boys and girls whose scientific skill, talent and ability indicate potential creative originality and warrant scholarships for their development.

2. To focus the attention of large numbers of scientifically gifted youths on the need for perfecting scientific and research skill and knowledge so that they can increase their capacity for contributing to the task of winning the war and the peace to follow.

3. To help make the American public aware of the role of science in the war and in the postwar reconstruction.

MEMBERSHIP ACTIVITIES

During the months of October and November, the SOCIETY had a net gain of 227 members, bringing the total to 5453 members or a gain of 4%. Sections which more than doubled this gain are:

Boston 18 new members, gain 12%; Canton 5 new members, gain 15%; Chattanooga 4 new members, gain 16%; Detroit 54 new members, gain 18%; Indiana 6 new members, gain 13%; Northwest 33 new members, gain 34%; Philadelphia 25 new members, gain 8%; Puget Sound 8 new members, gain 14%; and Wichita 3 new members, gain 13%.

PRODUCTION WELDING COURSE TO BE HELD IN CLEVELAND

The urgent need for welded ships, guns and planes, now that we are fighting in Africa, has increased the need for methods of speeding welding production. To answer this need, a special intensive five-day Welding Production Course will be held in Cleveland, Ohio, the week of January 11th, at the plant of The Lincoln Electric Co.

Organized for foremen, supervisors, production engineers, superintendents, managers and all executives interested in greater welding production, the course will concentrate on helping the men in attendance to get more welding production quicker at less cost in their own plants.

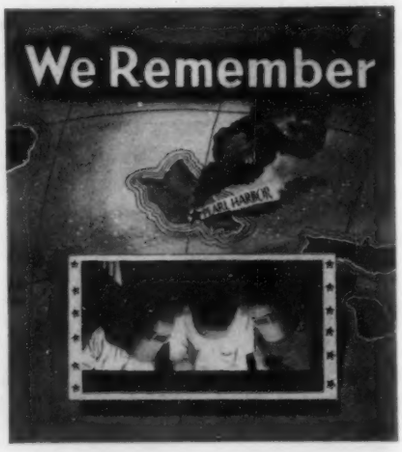
Lectures and practical demonstrations, plus an opportunity for each man to put into practice and test out the new welding methods and procedures outlined, will make up most of the intensive five-day schedule.

WELDING CLASSES AT EDWARD G. BUDD PLANT

Classes of instruction in the technique of the "Shotweld" system of welding stainless steel have been inaugurated at the Edward G. Budd Manufacturing Co.'s plant and are being given five days a week, according to an announcement today by J. R. Fetcher, welding and electrical engineer.

The course of instruction, which is being taken by Budd staff members, foremen and a number who have been chosen for welding supervision, includes a discussion of resistance welding, the Budd "Shotweld" system, stainless steel metallurgy, shop practice and supervision. Classes will continue throughout the year and eventually will be opened to all members of the organization.

Among the instructors are: Dr. C. A. Adams, world authority on electric welding, now consultant with Budd; Col. E. J. W. Ragsdale, one of the inventors of the "Shotweld" system, now chief engineer, Hi-Tensile division; Mr. Fetcher, chief electrical engineer; Joseph Winlock, chief metallurgical engineer; John MacKinney, welding research engineer; R. S. Phair, electronic engineer; Herbert Van Sciver, welding research engineer; Jan Van den Beemt, welding engineer; and Marshall Batchelor, chief welding supervisor.



Courtesy of Utilities Engineering Institute

We are welding students . . . concentrating, practicing, preparing for the day to take our places among the men who fabricate the weapons which are avenging Pearl Harbor. Yes, **WE REMEMBER!**

We are welding students . . . mastering a craft of importance in a war-torn world. We are eager to get going, to be part of the numberless crews that change steel into ships, and tanks, and planes, and guns.

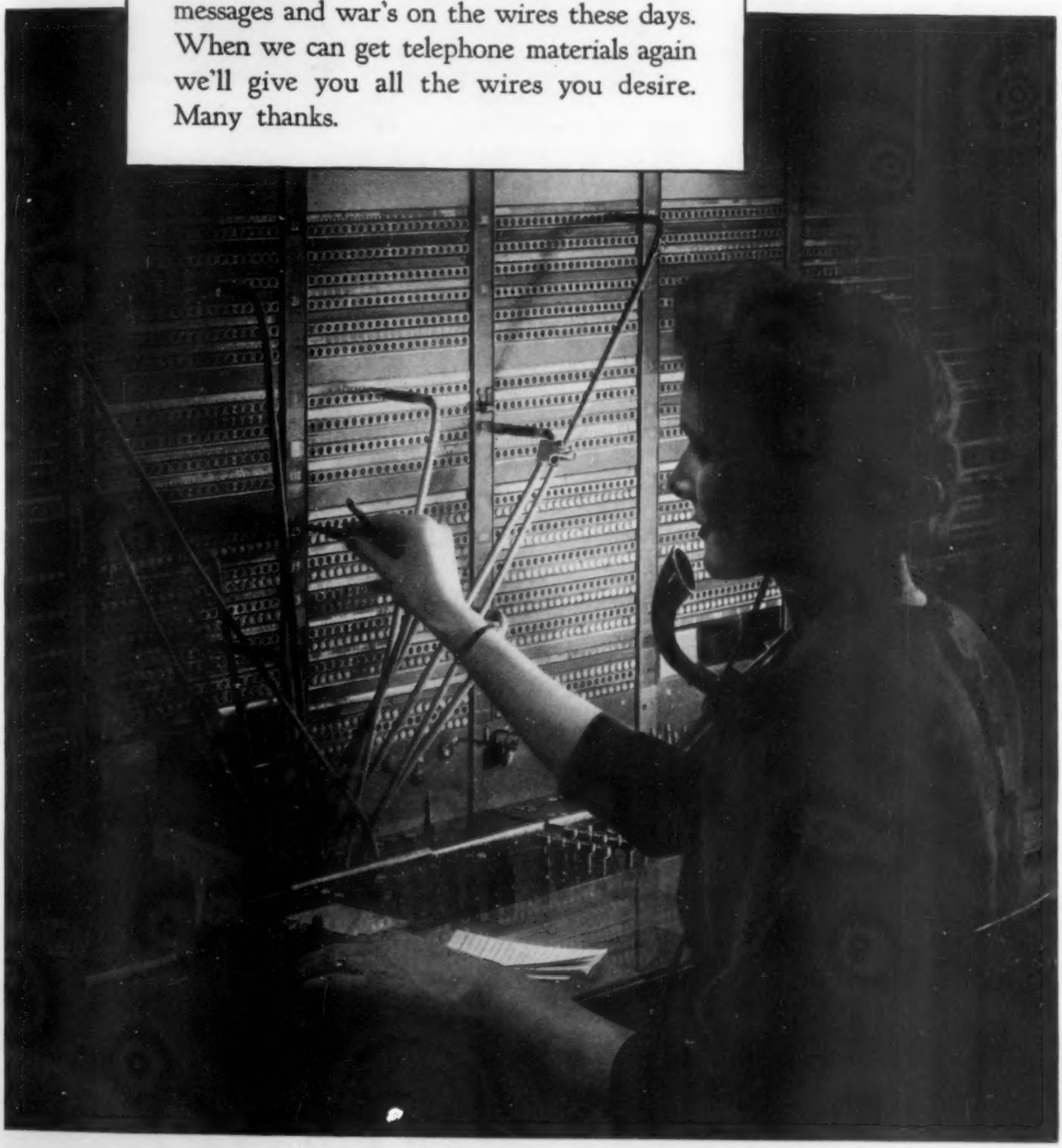
We are welding students . . . remembering Pearl Harbor . . . and the job at hand. But, still, we are men with vision, hope, and courage for we know that training reaches beyond the job at hand. Comes the Peace, we'll be the men to fashion the peace-time needs that make for comfortable and healthful living all over the globe.

We are welding students . . . now . . . but soon our energy and skill will be added to those of our fellow craftsmen whose rods and torches are dedicated to swift vengeance . . . . **YES, WE REMEMBER!**

"AN URGENT CALL FOR YOU"

"Please do not make Long Distance telephone calls to war-busy centers unless it is really necessary."

That helps keep the lines open for war messages and war's on the wires these days. When we can get telephone materials again we'll give you all the wires you desire. Many thanks.



BELL TELEPHONE SYSTEM

THE INSTITUTE OF METALS

Bibliography of the Literature Relating to Constitutional Diagrams of Alloys, by J. L. Haughton, D.Sc. (Institute of Metals Monograph and Report Series, No. 2). Limp cloth. Demy 8vo. Pp. iv + 163. 1942. London: The Institute, 4 Grosvenor Gardens, S.W.1. Price 3*s*. 6*d*., post free.

This Bibliography contains over 5000 references to papers dealing with the constitution of binary, ternary and higher alloy systems, both ferrous and non-ferrous. References have been included not only to papers of a purely constitutional character but also to many X-ray and physical-property studies of alloys, which have some bearing on the constitution. To furnish some guide among the references (which in a few systems exceed 100), asterisks have been placed against those in the originals of which a new equilibrium diagram, or portion of one, is to be found. It is intended that the Bibliography shall be used in conjunction with the abstracts that the Institute has published since its foundation, first in the *Journal* and then in *Metallurgical Abstracts* (Series II); for convenience, therefore, references have been included to these abstracts, whenever such exist.

The Bibliography is thoroughly up to date and contains references to all papers seen up to the time of going to press. It should prove invaluable to all research workers in metallurgy, works' metallurgists, and others interested in the constitution of metallic alloys.

TIN SOLDERS

Tin Solders, by S. J. Nightingale and O. F. Hudson, is a modern study of the Properties of Tin Solders and Soldered Joints. This revised edition describes the results of most recent research. Price $2.75, published by Chemical Publishing Co., Inc., Brooklyn, N. Y.

SPOT WELDING SAVES TIME AND MATERIAL IN PRODUCTION OF G-E SWITCHGEAR

More than 56,000,000 spot welds will be made in G-E switchgear parts this year, a saving of the same number of rivets or bolts which these parts would ordinarily require. Arc welding of these parts would require nearly 500,000 lb. of heavily coated electrodes. Spot welding pays dividends in material when contrasted with these other methods of doing the same job.

This process of joining metals together makes it possible to make switchgear parts in the shortest time, with the least material, without impairing quality. The two metals to be welded are pressed together between the electrodes and the current is turned on. The pressure applied forces and holds the pieces together to make the weld. Accurate timing, so important in spot welding, is made possible by electronic control which maintains split second control of the welding operation.

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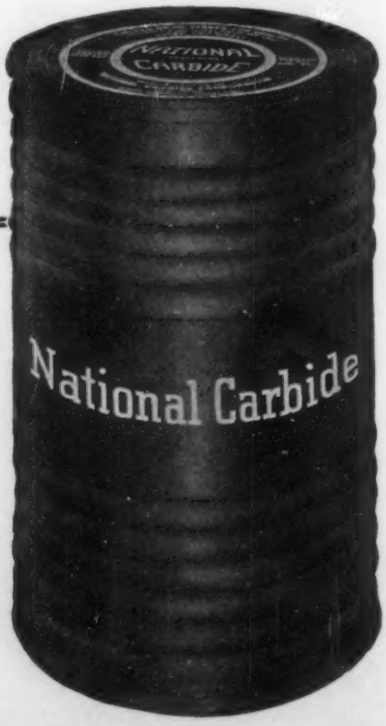

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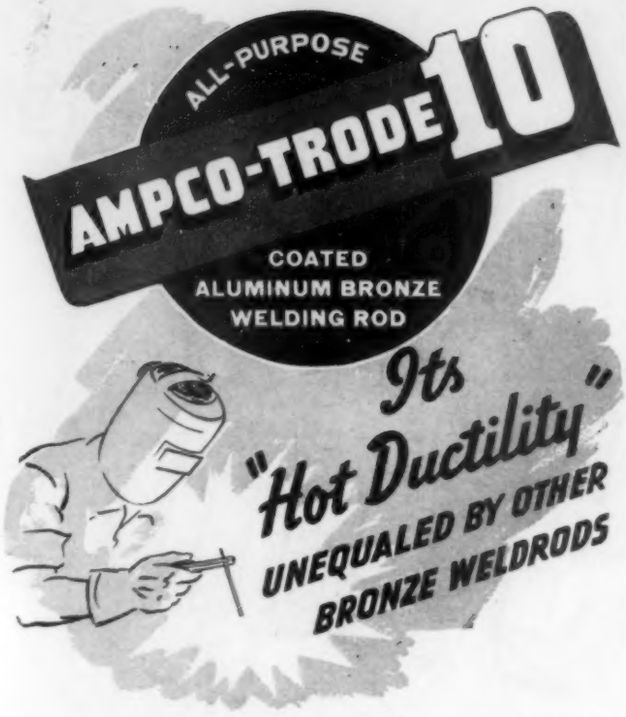

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INDEX TO ADVERTISERS

Air Reduction Sales Co. . . . Outside back cover
American Brass Company 65
American Chain & Cable Company, Inc. . . . 49
American Telephone & Telegraph 37
Ampco Metal, Inc. 39
Anti-Borax Compound Company 50
Arcos Corp. . . . . Inside front cover
Bastian-Blessing Co. 42
Champion Rivet Company 57
Electroloy Co., Inc. 48
Eutectic Welding Alloys Co. 46
Foote Mineral Company 51
General Electric Co. . . . . Insert 66 & 67
Haynes Stellite Co. 3
Hobart Bros. Co. 1
International Nickel Co. 61
The Lincoln Electric Co. . . . . Inside back cover
The Linde Air Products Company 4
P. R. Mallory & Co., Inc. 44
Metal & Thermit Corporation 45
National Carbide Corporation 38
National Time & Signal Corp. 62
Oakite Products, Inc. 42
Page Steel & Wire Division 49
Ransome Machinery Co. 43
Resistance Welder Mfrs. Association 68
Sciaky Bros. 47
Shawinigan Products Corp. 50
A. O. Smith Corp. . . . . 40 & 41
Union Carbide and Carbon Corp. . . . . 3 & 4
United Electronics Co. 55
Victor Equipment Co. 59
Wilson Welder & Metals Co., Inc. 53

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Even holders of "A" gas rationing cards can travel 400 miles a week on this ingenious motor cycle. The cycle, built in the job welding shop of S. S. Brewer, Kirkland, Wash., averages 100 miles on a gallon of gasoline; moves along as fast as 35 miles an hour.

Courtesy Hobart Bros. Co., Troy, Ohio

This motor cycle, as you can see in the picture, is made from a conglomeration of materials. The gas engine once ran a family washing machine; frame was pipe scrap; gas tank, welded right to the frame, was two old headlight shells. Cycle has a front-wheel hand brake and a rear-wheel foot brake. It is equipped with a secondhand gear change box and clutch.

"Sure," says Mr. Brewer, "it takes a lot of 'fancy' welding to assemble this cycle. But any good job welder can do it. And all parts are salvage parts but the wheels and tires."

SPECIFIC HEATS

"The Specific Heats of Certain Gases Over Wide Ranges of Pressures and Temperatures" is the title of Bulletin No. 30, a recent publication of the Cornell University Engineering Experiment Station. The gases are air, carbon dioxide, carbon monoxide, ethylene, hydrogen, methane, nitrogen and oxygen; the temperature is from 0 to 4000 F.; and the pressure range is from 0 to 10,000 pounds psi.

This bulletin gives the general equations which determine the effect of pressure on the specific heats of the gases, within ranges of temperature and pressure encountered most frequently in engineering practice. For the gases considered in this paper, the variations of specific heats with temperature and pressure are also shown graphically.

The authors of this bulletin are Frank O. Ellenwood, John Edson Sweet, Professor of Engineering and Head of the Department of Heat-Power Engineering, Nicholas Kulik, formerly McMullen Graduate Scholar in the Sibley School of Mechanical Engineering, and Norman R. Gay, John Edson Sweet, Research Associate, all of Cornell University.

Single copies of this bulletin may be secured without charge by writing to the Engineering Experiment Station, Cornell University, Ithaca, N. Y. The price for additional copies sent to the same person is 50¢.

HUSTON ASSISTANT TO PRESIDENT, LUKENS STEEL CO.

Charles L. Huston, Jr., Director of Personnel Relations of Lukens Steel Co., Coatesville, Pa., and a member of the company's Board of Directors, has been appointed Assistant to the President of the company, according to an announcement by Robert W. Wolcott, President.

Mr. Huston joined Lukens as Director of Personnel Relations in September 1939, after serving ten years with the American Rolling Mill Co., Middletown, Ohio. With the latter concern, he spent five years in the Metallurgical Department and five years on the company's personnel relations staff in public relations, employment and training work. At the time of his resignation to join Lukens, he was Assistant Staff Supervisor of Employment and in charge of introductory training.

Mr. Huston was born in Coatesville in May 1906, where he attended grade school and graduated from the Hill School in Pottstown, Pa., in 1924. He graduated from Princeton University with a degree of Bachelor of Science in 1928 and spent the following year doing special studies in metallurgy at Massachusetts Institute of Technology, going from there to the American Rolling Mill Co.

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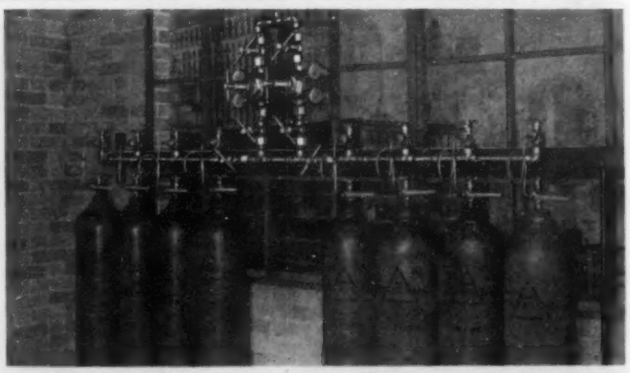

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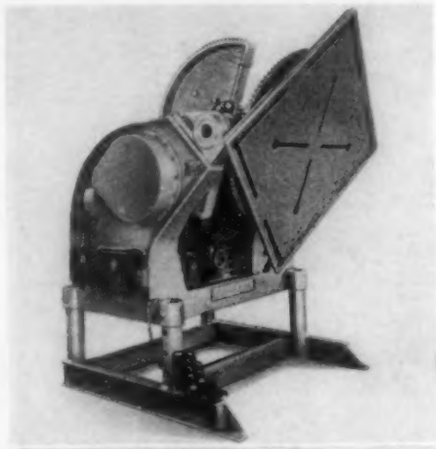

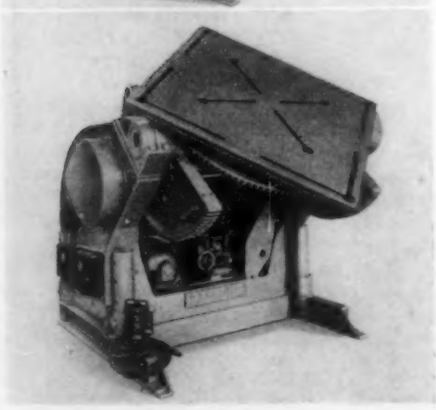

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Mr. Huston is a member of the Industrial Relations Commttee of the American Iron & Steel Institute and a member of the Association of Iron & Steel Engineers. He has recently served as a special mediating officer for the National War Labor Board. He is a member of the American Branch of the Newcomen Society of America, of the Executive Committee of the Chester County Council of the Boy Scouts of America and of the Board of Managers of the Coatesville Hospital. His clubs include: the Delta Psi Fraternity, the Princeton Club of Philadelphia, the Quadrangle Club of Princeton, Merion Cricket Club of Haverford and the Coatesville Country Club.

NEW BOOKLET ON A.-C. WELDING

Speed is increased 20 to 30% and power costs are cut one-third with the Flexarc A-C Welders described in a new booklet by Westinghouse Electric & Mfg. Co.

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A copy of B-3136 may be secured from Department 7-N-20, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

I.A.A. PUBLICATIONS

Oxy-Acetylene Cutting: The major modification in the new edition has to do with the cutability table of ferrous metals and a greatly amplified section under the subject of "Flame Machining" in which category now falls some of the most significant volume applications. The price remains at 25 cents per copy.

Welding Codes and Specifications: A handy reference to material specifications and construction codes for the welding fabricator. This completely revised publication reflects recent changes in regulatory codes and specifications and includes the new N. E. (National Emergency) steels. The price remains at 15 cents per copy.

Safe Practices for Installation and Operation of Oxy-Acetylene Welding and Cutting Equipment: In the revision as well as in the original preparation of this document, the committee borrowed freely from the many Boards, Bureaus, and Commissions that issue Standards, Regulations and recommendations having to do with the industry. Included are separate chapters on Eye Protection, Safe Clothing, Fire Prevention, Accident Prevention, and Industrial Health. Numerous problems that have been troublesome to the industry as well as to regulatory authorities have, in this revised publication, been ironed out to the satisfaction of all interests. The price remains at 25 cents per copy.

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SPOT WELDS IN SWITCHGEAR CONSTRUCTION

Spot welding has replaced other fabricating methods in many instances in the manufacture of steel switchgear at General Electric with important savings in time and material resulting.

For example, in joining the structural angle and gusset plates to form sturdy corners for switchgear equipment, spot welding has proved to be five times faster than arc welding, nearly that much faster for bolting and almost six and a half times faster than riveting.

Spot welding the many studs required

on the rear panels of switchgear makes apparent savings in time by eliminating the seven steps required by the method of punching a hole in the panel, threading the hole, countersinking for the screw head, inserting the screw, peening the edge of the screw so it will not turn, grinding the peened surfaces smooth and filling in the rough surface with filler.

By spot welding the silver-steel contact disks used in a selector switch, a 50% saving in silver is realized because the disks need not have stems as would be the case if riveting or bolting were used (see illustration).

NEW AWARD PROGRAM FOR ENGINEERING STUDENTS ANNOUNCED BY LINCOLN FOUNDATION

The James F. Lincoln Arc Welding Foundation of Cleveland, Ohio, sponsor of the 1937–38 and 1940–42 nationwide $200,000 arc-welding award programs, today announced its first award program in the field of undergraduate engineering study.

The Foundation's new project is the $6750 Annual Engineering Undergraduate Award and Scholarship Program. Its object, as expressed in Rules and Conditions governing participation, is "to en-

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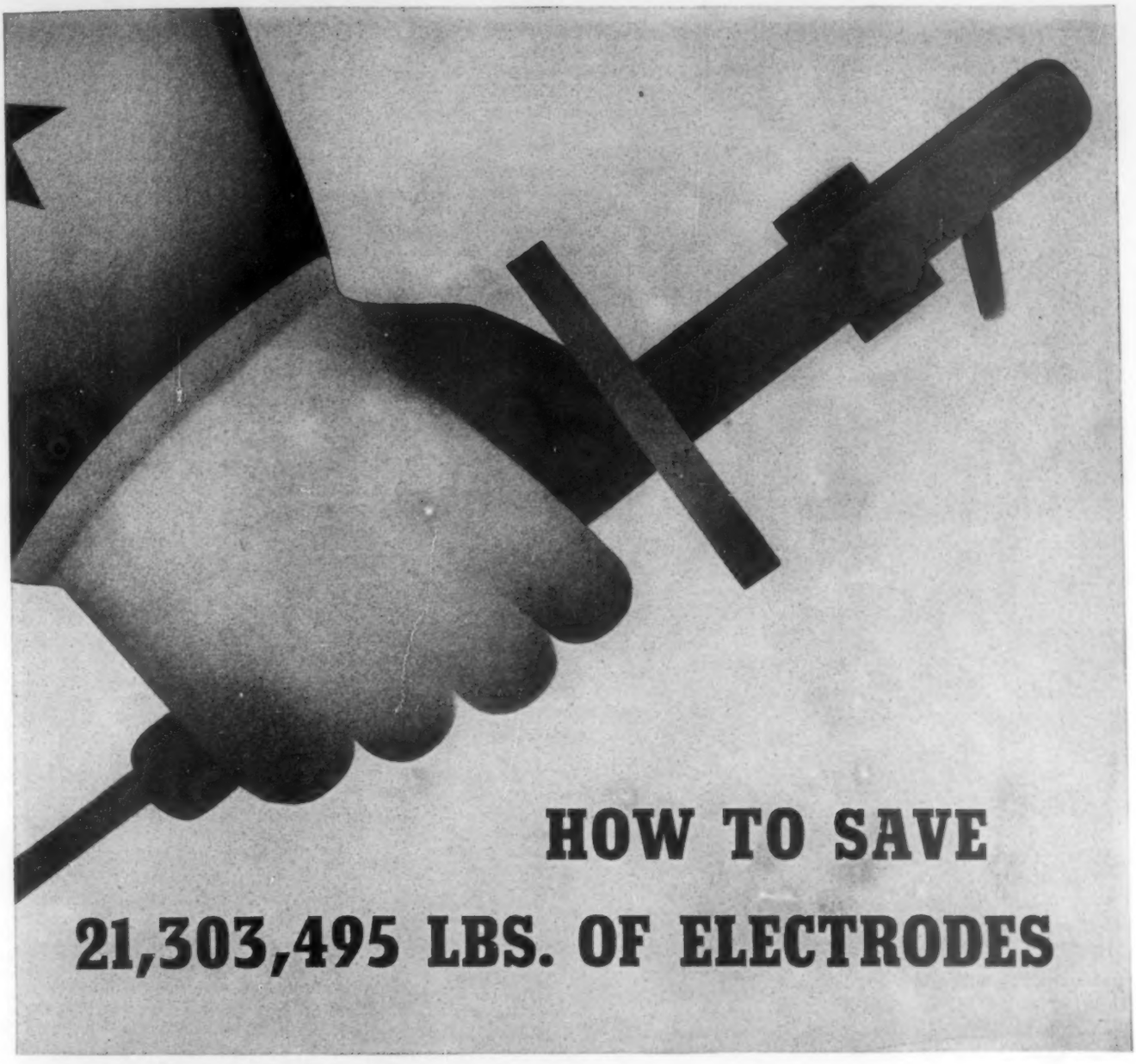

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THE lowly stub end. Only a few inches of metal, weighing about a quarter of an ounce. Yet if it were possible to use half an inch more of every electrode, the reduction in stub end waste would save, at the nation's present consumption rate, approximately 21,303,495* pounds of electrodes annually.

To help stop this waste, use as much of the length of the coated surface as possible, leaving, on the average, a total stub end of no more than 1½ inches; position the work and use the largest sizes and longest rods that are practical.

Have the welders in your organization *turn in all stub ends.* This practice is not only a check on waste, but it helps in the collection of vitally needed segregated scrap.

*estimated on the basis of 5/16" electrodes, 14 inches long.

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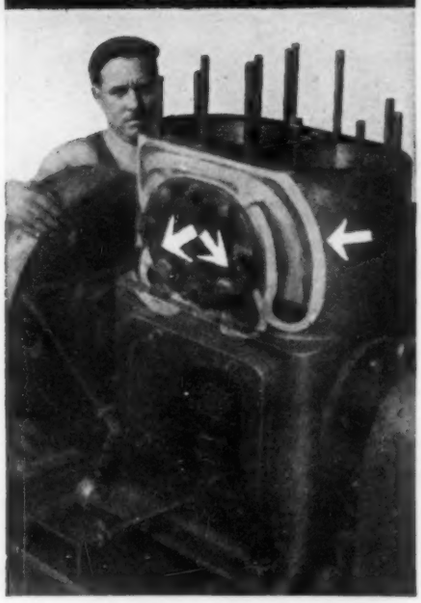

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courage engineering students to study arc-welded construction so that their imagination, ability and vision may be given opportunity to extend knowledge of this method and thus aid the war effort and the economic reconstruction in the peace which is to follow."

The Program offers $5000 in student awards and $1750 in scholarships for the departments of the institutions in which the award-winning students are registered.

There are 77 student awards—a first award of $1000, second of $500, third of $250, four awards of $150, eight of $100, twelve of $50 and fifty of $25.

There are seven scholarships of $250 each. The school of the first award winner will receive four scholarships totaling $1000; the school of the second winner will receive two scholarships totaling $500; and the school of the third winner will receive one scholarship of $250.

The winning students will receive an additional honor, since the scholarship in his school will be given his name as: "The John Doe Scholarship of the Lincoln Foundation."

Any resident engineering undergraduate student registered in any school, college or university in the United States, giving a course in any branch of engineering or architecture, leading to a degree or any cadet registered in the United States Military Academy, United States Naval Academy and Coast Guard Academy is eligible to submit a paper in the award program.

The awards will be made for papers describing the conversion from other methods to arc-welded construction of parts of machines, complete machines, trusses, girders or structural parts. The subject may be something which the student has observed in school shops, magazines, books, printed matter or elsewhere; or he may conceive of a subject which has never been built but could be built by arc welding. The Foundation encourages the preparation of the type of paper which will not interfere, seriously, with the student's regular college activities.

It will not be necessary that the machine or structure or part be actually built, but the method of construction, or the design must be described in the paper.

A paper may be submitted by any group of students but no one student or group shall participate in the writing of more than one paper. Each student author, or group, must have actually organized and prepared the description, or design, which is presented in the paper.

If the paper covers a project, the project may have been started before December 1, 1942, but it must have been completed within the period December 1, 1942, to April 1, 1943.

The jury of award will be drawn from various branches and institutions of engineering education. Selection of the jurors will be under the direction of Dr. E. E. Dreese, Chairman of the board of trustees of The James F. Lincoln Arc Welding Foundation. Dr. Dreese is head of the department of electrical engineering of the Ohio State University.

Other members of the Foundation Board of Trustees are: W. B. Stewart, senior partner, McKeehan, Merrick, Arter & Stewart of Cleveland; H. R. Harris, vice-president, The Central National Bank of Cleveland.

Further details of the $6750 Annual Engineering Undergraduate Award and Scholarship Program may be obtained by writing The James F. Lincoln Arc Welding Foundation, P. O. Box 5728, Cleveland, Ohio.

MILLS HELPS INDUSTRY INTEGRATION

Ellsworth L. Mills, vice-president of The Bastian-Blessing Company, has been named assistant chairman of the Industry Integration Committee for the M-54 and M-55 it was announced today by the office of the Chief of Ordnance.

Ellsworth L. Mills

Integration committees of this type are now being set up throughout industry, their purpose being to furnish "clearing houses" for handling important problems concerning ordnance production.

As assistant chairman of the committee, Mr. Mills will work closely with an Ordnance officer chairman as well as other prominent manufacturers from various sections of the country.

OBITUARY

John E. Greiner Dies, Was Honorary A.S.C.E. Member*

John Edwin Greiner, 83, nationally known as a bridge engineer, and a former director and honorary member of the American Society of Civil Engineers, died Nov. 15th at his home in Baltimore.

He had served both the state of Maryland and Baltimore City as consulting engineer, was chairman of the Port Development Commission from 1920 to 1927, and had been assistant engineer of the Baltimore & Ohio Railroad.

Honored many times by the Am. Soc. C. E., Mr. Greiner won a gold medal in 1896 for a paper on "The Life of Bridges"

*Reprinted from Nov. 19, 1942, Issue of *Engineering News-Record*.

keep them WELDING

for

VICTORY

This welder is a weapon in the hands of the United Nations! When German Messerschmidts and Japanese Zero fighters were examined by United Nations experts, they showed no trace of spot welding in their fabrication.

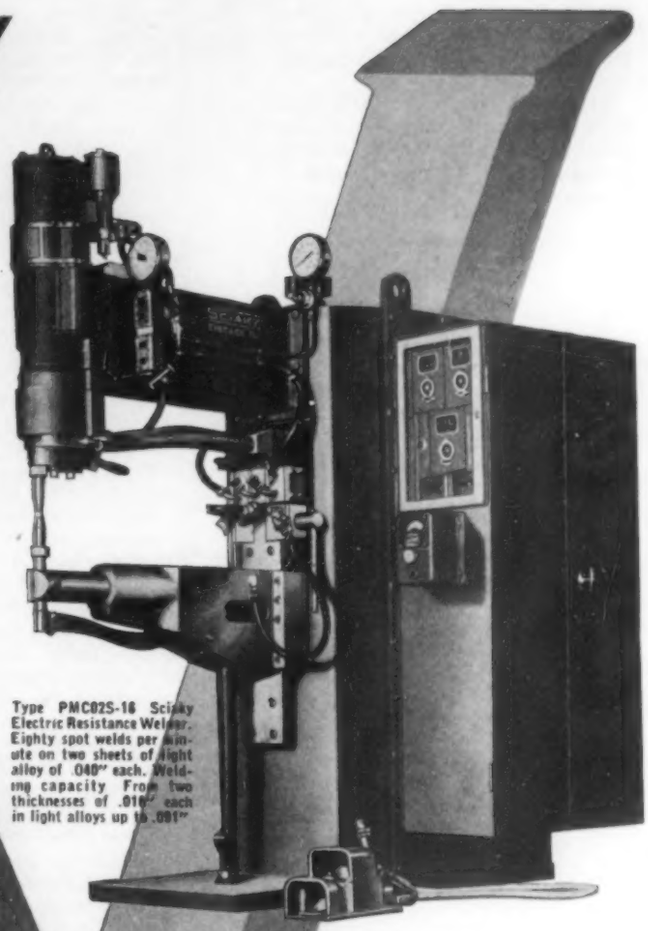
Mass production methods, characteristic of American genius, applied in the aircraft industry, are wiping the enemy out of the sky.

The contribution of spot welding to these methods has been made possible thanks to these basic Sciaky principles:

STORAGE OF ENERGY
with
PREHEATING

VARIABLE PRESSURE
with
PRECOMPRESSION

These exclusive features are incorporated *only in Sciaky Welders.*



Type PMC02S-16 Sciaky Electric Resistance Welder. Eighty spot welds per minute on two sheets of light alloy of .040" each. Welding capacity From two thicknesses of .010" each in light alloys up to .091"

WRITE FOR DESCRIPTIVE LITERATURE

Pamphlet describing the Sciaky Process of Electric Resistance Welding mailed free. Use company letterhead, please

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Manufacturers of a Complete Line of D.C. and A.C. Electric Resistance Welding Machines
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VULTEE AIRCRAFT, INC.

SCIAKY

PROCESS ELECTRIC RESISTANCE WELDING
STORED ENERGY · VARIABLE PRESSURE
WITH PREHEATING · WITH PRECOMPRESSION

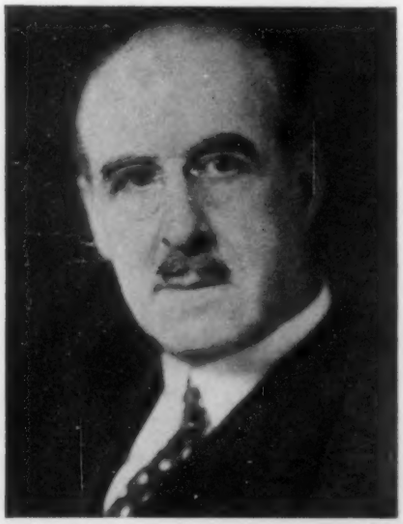
and in 1915 received the James Laurie prize for a discussion on "Coal Piers on the Atlantic Seaboard." He became an honorary member of the society in 1932. Heading his own company since 1908, Mr. Greiner was engaged in construction of many bridges and buildings throughout the East. In 1917 he was a member of the U. S. railroad commission sent to Russia by President Wilson, Mr. Greiner's duties being to pass on the load capacity of Russian bridges.

Probably his company's most ambitious work in relation to Maryland has been the preparation of plans for the entire bridge program of the Maryland Roads Commission.

OBITUARY

Dr. F. M. Becket

Dr. Frederick M. Becket, a consultant to Union Carbide and Carbon Corporation, died December 1st at the Roosevelt Hospital, New York, N. Y. He was formerly President of Union Carbide and Carbon Research Laboratories, Inc., and former Vice-President of Union Carbide Company, Electro Metallurgical Company, and Haynes Stellite Company, all Units of Union Carbide and Carbon Corporation. He was 67 years of age.



Dr. Becket was born in Montreal, Canada, in 1875. He attended elementary school in Montreal, and then went to McGill University, graduating with a Bachelor of Science degree in 1895. He came to the United States in that year. He received a Master of Arts degree from Columbia University in 1899.

Dr. Becket was a foremost pioneer in the electrometallurgical industry. As a tribute to his work, he received numerous honors in the electrochemical and metallurgical fields. In 1924, he received the Perkin Medal from the associated Chemical and Electrochemical societies. He was President in 1926 of The Electrochemical Society, was elected an honorary member in 1934, and in 1937 received the Society's Acheson Medal Award. He is also a Past-President of the American Institute of Mining and Metallurgical Engineers (1933) and of the Chemist's Club (1939). In 1940, the Franklin Institute presented Dr. Becket with the Elliott Cresson Medal. Also, in 1940, he received one of the Modern Pioneers Awards of the National Association of Manufacturers. In 1929, Columbia University bestowed upon him the honorary degree of Doctor of Sciences, and in 1934, McGill University conferred upon him the honorary degree of Doctor of Laws. For many years, he has been a contributor to technical publications in the chemical and metallurgical fields.

Shortly after the turn of the century Dr. Becket originated and commercialized the fundamental principle of producing low carbon ferroalloys and alloying metals by reducing ores in the electric furnace with silicon instead of carbon. Although such products had been made earlier in Europe, and to a much smaller extent in this country, by reduction with aluminum, the more costly aluminothermic method was discontinuous and accordingly not appropriate to large-scale production. In his hands, silicon reduction yielded the first electric-furnace ferrovanadium produced in this country, and probably in the world; ferrotungsten of commercial quality from the high-phosphorus domestic ores; ferromolybdenum direct from the natural sulphide; and, most important of all low-carbon ferrochromium. It was in 1918 that he developed the electric-furnace technique of producing ferrozirconium, used at that time for light armor plate, and now widely employed for improving quality steels.

In order to serve alloys other than steels and irons, Dr. Becket early applied silicon reduction to the electric-furnace production of chromium and manganese metals, almost free from iron and thus suitable for many alloys based on copper and nickel. His efforts also led to the tonnage production of silicon metal, which is a prime factor in the strong alloys of aluminum so necessary to aviation.

Dr. Becket early joined steelmakers in the pioneer domestic promotion and development of vanadium and molybdenum engineering steels, which have long been prominent in automotive manufacture. He projected the high-chromium steels and irons; to the chromium-nickel stainless steels he contributed stabilization with ferrocolumbium; and for the joining of steels, irons and copper alloys, he devised welding rods of correct metallurgical properties.

Dr. Becket was a member of many engineering and scientific societies. He was a Fellow of the American Association for the Advancement of Science, a member of the American Institute of Mining and Metallurgical Engineers, American Chemical Society, The Electrochemical Society, Mining and Metallurgical Society of America, American Society for Metals, Iron and Steel Institute of London, American Institute of Chemical Engineers, and the New York Academy of Sciences. He also was a member of the Chemists', Engineers' and Mining Clubs, of New York, and of the Niagara Club of Niagara Falls, New York.

Dr. Becket is survived by his wife, Geraldine McBride Becket; two children, Mrs. Paul H. Folwell, of Bronxville, N. Y., and Mrs. Ruth B. Tranter, of this city; one sister, Miss Christina A. Becket, of Montreal; and three brothers, Dr. George C. Becket, of East Orange, N. J., Ralph A. Becket, of Montreal and Frank W. Becket, of Montclair, N. J.

GEAR SET WELDING

The accompanying illustration shows a welder at one of the General Electric's marine gear shops works on a high-speed pinion which will be part of the geared-turbine propulsion equipment for a Navy

vessel. Welding has helped considerably in conserving materials and speed production of propulsion sets. One G-E plant has nearly doubled its promised delivery of propulsion sets for this year.

ELECTROLOY ALLOYS for RESISTANCE WELDING ELECTRODES and DIES

Spot
Seam
Butt
Flash
Projection

ELECTROLOY ALLOYS were developed specifically for the resistance welding industry. ELECTROLOY ALLOYS cover the full range of physical properties necessary to the manufacturers and users of resistance welding equipment.

Our engineers will be glad to make recommendations for your special electrodes. Submit samples or specifications.

Catalog and prices available on request.

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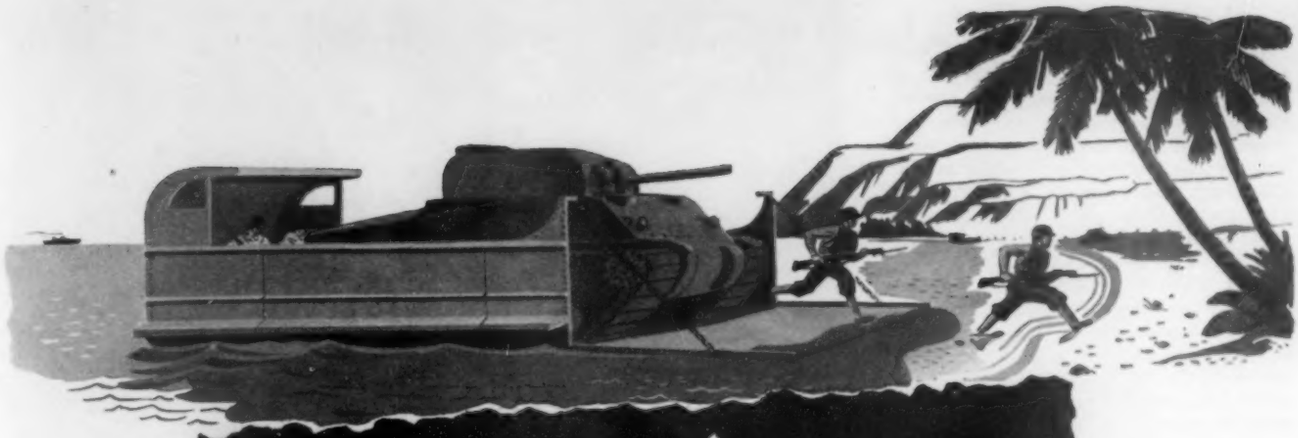


that's the job FOR WHICH PAGE DEVELOPED ITS ELECTRODES FOR WELDING ARMOR PLATE

★ ★ ★ ★ ★ ★ ★ ★ ★ ★

AND news has it that so many of these great, armored tanks have come off the line—welding automotive production genius resulted in such a tremendous flow of finished units—that, for the time, at least, there are plenty of them.

The **PAGE** organization hopes that America will not need to turn to full-time tank production again—but that the presence on many fronts of the fine power of tanks we now have will help end this war.

For such tanks as will be made, **PAGE** will be able to continue to supply electrodes—developed exclusively by **PAGE**—which have passed all ballistic tests.

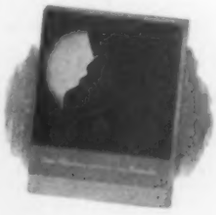
WELDING STAINLESS STEEL

PAGE also has for wartime welders of stainless a range of Stainless Steel Electrodes from which it is relatively easy to select the electrode that will give a deposit that equals the stainless being welded.

But, again, a word of caution. No matter what you weld, be sure first that you use electrodes of the right size. Lean toward larger diameters. Don't waste time and material by faulty technique or deposit of excess metal. Use electrodes right down to the holder.

WELDING STAINLESS?

You will find a great deal of practical information on Stainless Steel and Stainless Steel Welding procedure in this 9x12 booklet. Get a copy from your local PAGE *distributor.*



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MANHOLE COVERS

"Change-over to welded parts—one part at a time"—has long been the plea of leading welding engineers. A typical example of the economy and practical value gained by following this advice may be found in the engineering files of the Mississippi Valley Barge Line Company, Cincinnati, Ohio. This company enjoyed a savings of $21,681 on a single contract by changing from riveted to welded manhole covers on barges and boats they constructed.

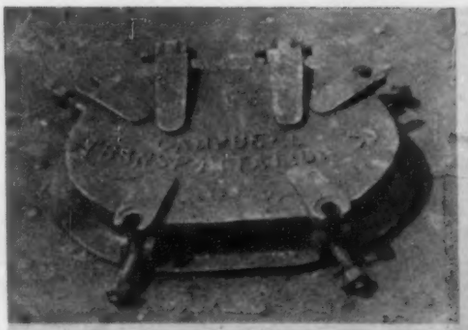
Conventional manhole covers are made of steel castings. The rim is riveted or welded to the deck; cover, with a rubber gasket, is attached to the rim. This manhole cannot be conveniently mounted flush with the deck.

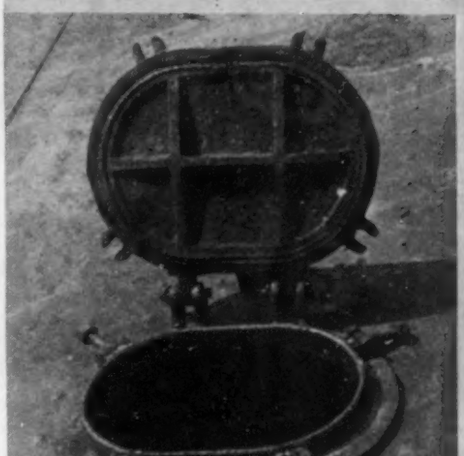
On a contract for 45 large barges—each requiring 22 manhole covers—H. C. Elliott, superintendent of maintenance, suggested that all covers be welded completely. Covers of welded construction, Elliott said, could be mounted flush and would save time, money and labor.

The value of his suggestion is shown in the photographs shown on this page, by courtesy of Hobart Brothers Co., and in this cost analysis:

	Cast Steel Cover	Welded Cover
Cast steel removable cover, 58 lb. @ 15¢ per lb.	$ 8.70	
Machining removable cover casting	6.00	
Cast steel rim, 60 lb. @ 15¢ per lb.	9.00	
Machining cast steel rim	6.50	
Bolts, nuts and cotter pins	1.50	
Gasket	1.00	$ 1.00
Top plate burned out of 5/16-in. plate		.85
1 x 1 1/4-in. angle rolled from 1/4-in. plate and ears bent down		.40
Hub cast from malleable iron, machined and drilled for pins		1.50
5 spring steel lock springs, punched and formed @ 20¢ each		1.00
5 pieces of drill rod, 3/8 in. diameter		.15
2 small fiber gaskets		.20
Cadmium plating hub, springs		.20
Clamping and welding the assembly		1.00
Welding doubling plate under deck to reinforce deck and to form gasket surface for cover		
	$32.70	$10.80

Welded design saved $21.90 on each cover. Since each boat required 22 covers—savings per boat was $481.80. Savings on entire contract of 45 boats was $21,681.





Riveted Cover

Courtesy Hobart Bros. Co., Troy, Ohio

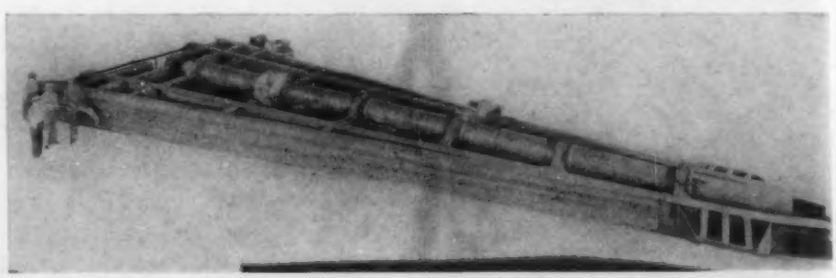
Welded Cover

Besides the savings in money, welded covers were stronger, more attractive—and could be mounted flush with the deck.

DREDGE LADDER

This is a 35-ton dredge ladder built entirely by arc welding. Due to the

Courtesy Hobart Bros. Co., Troy, Ohio



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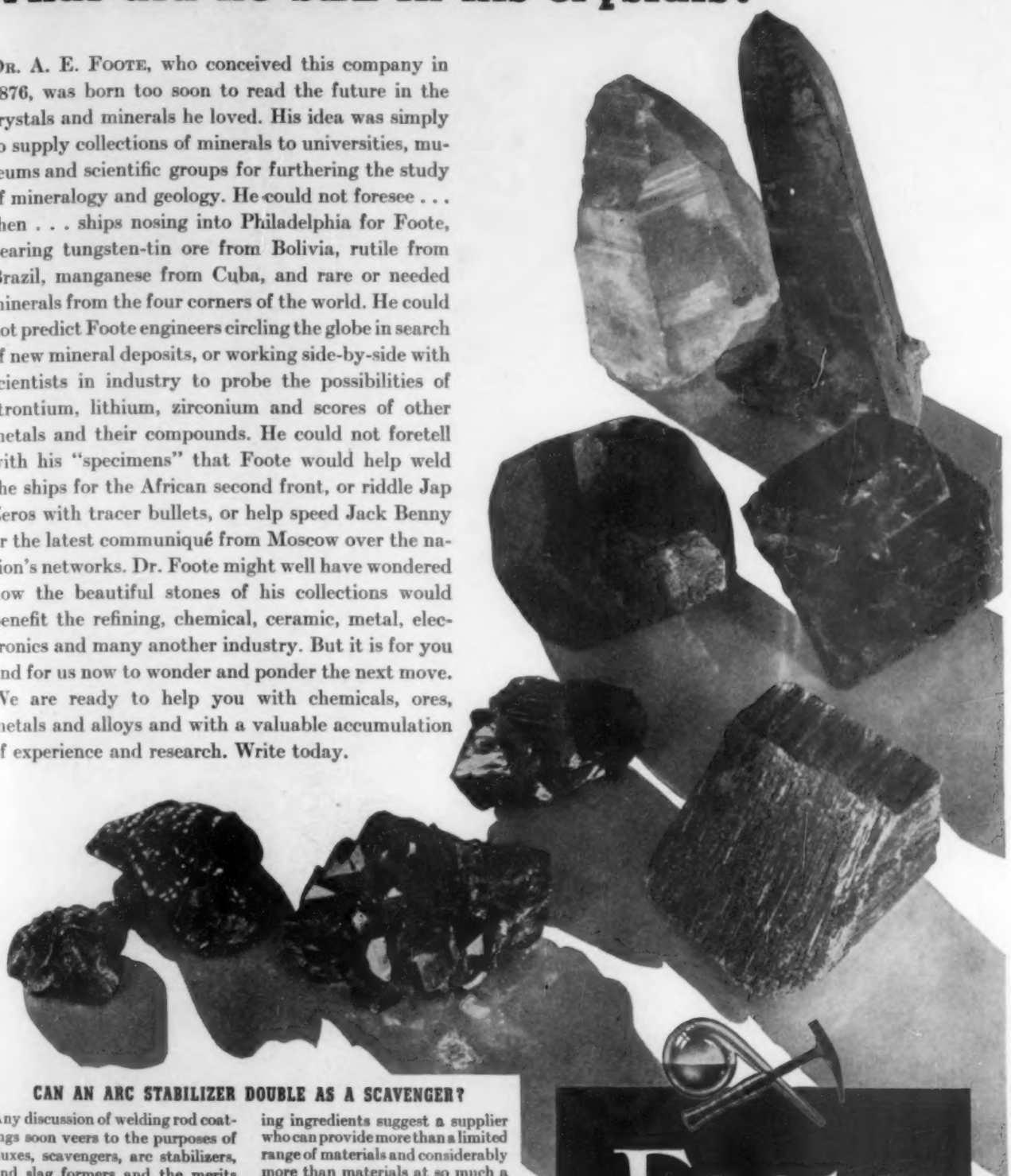
What did he SEE in his crystals?

DR. A. E. FOOTE, who conceived this company in 1876, was born too soon to read the future in the crystals and minerals he loved. His idea was simply to supply collections of minerals to universities, museums and scientific groups for furthering the study of mineralogy and geology. He could not foresee . . . then . . . ships nosing into Philadelphia for Foote, bearing tungsten-tin ore from Bolivia, rutile from Brazil, manganese from Cuba, and rare or needed minerals from the four corners of the world. He could not predict Foote engineers circling the globe in search of new mineral deposits, or working side-by-side with scientists in industry to probe the possibilities of strontium, lithium, zirconium and scores of other metals and their compounds. He could not foretell with his "specimens" that Foote would help weld the ships for the African second front, or riddle Jap Zeros with tracer bullets, or help speed Jack Benny or the latest communiqué from Moscow over the nation's networks. Dr. Foote might well have wondered how the beautiful stones of his collections would benefit the refining, chemical, ceramic, metal, electronics and many another industry. But it is for you and for us now to wonder and ponder the next move. We are ready to help you with chemicals, ores, metals and alloys and with a valuable accumulation of experience and research. Write today.



CAN AN ARC STABILIZER DOUBLE AS A SCAVENGER?

Any discussion of welding rod coatings soon veers to the purposes of fluxes, scavengers, arc stabilizers, and slag formers and the merits of various materials for producing their effects. Seldom is one property of a rod coating required to the exclusion of others. And seldom does an arc ingredient perform a single mission. The complex nature of rod coating requirements and the multiple advantages of rod coating ingredients suggest a supplier who can provide more than a limited range of materials and considerably more than materials at so much a pound. This, to a helpful degree, Foote offers—sound thinking in chemistry, metallurgy, mineralogy, and responsibility for culling the whole big field of Foote welding products to find precisely what you need.

Have you a copy of "Foote Welding Materials"? If not, write us.

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West Coast Representative: GRIFFIN CHEMICAL CO., San Francisco, California

shortage of shapes, its 70-ft. side beams had to be split and made of size with welded plates. Perfect alignment was achieved by skip welding. All joints in the entire structure were "Vee" joints. Job was constructed at the Converse Bridge & Steel Co. of Chattanooga, Tenn., under the direction of R. P. Smith, superintendent. Six electric-driven arc welders were used on the job.

PHOTOS OF ARC-WELDING JOBS IN BRAZIL

Courtesy The Lincoln Electric Co., Cleveland, Ohio.

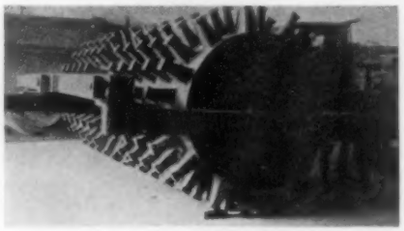


Fig. 1

This is an earth roller level for the Highway Department. It is constructed of Armco 3/8-in. hot-rolled sheets and welded throughout with 5/32- and 1/4-in. electrodes. The total weight of the roller level is approximately 3 tons, and when working it is filled with wet sand to a weight of 9 tons.

Fig. 2

Photo shows the end of a dragline used for river straightening which had one of its parts broken. This was repaired by welding using shielded arc electrode, 5/32- and 1/4-in. sizes. This dragline end is made of manganese steel and the total weight is 5 tons. It has been in service for approximately one year from date of repair with satisfactory results.

Fig. 3

This 120-passenger streamlined train was used by the Viacao Ferrea Rio Grande do Sul, and was completely welded on the inside under the supervision of the Armco Welding Division of Porto Alegre.

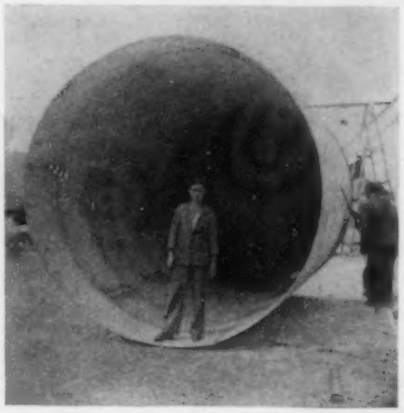


Fig. 4

As plain sheets were not available, a special culvert was built to serve as a gasoline tank. The tank utilized 10-gage steel and has a diameter of 3 meters. It was welded on the inside with shielded arc electrode, 1/8-in. size.

INDUCTION HEAT SAVES TIME IN BRAZING OPERATION

High-frequency induction heat, used in a brazing operation on certain parts for war goods being produced at a General Electric plant in the east, has reduced the time for the operation from 40 min. to 40 sec., and has eliminated the need for highly skilled workers to perform the work.

"The brazing operation was previously done with torches," explains J. P. Jordan, of the G-E Radio, Television and Electronics Dept. "Because a high quality joint was needed, only highly skilled workers could be used. Great care had to be taken not only during the operation, but also in its inspection. The average time per joint was about 4 min. With the application of electronic high-frequency induction heat, the time required for the operation has been reduced to 40 sec. Women operators are now used, a uniform joint is achieved and, because of uniformity, inspection of this operation is eliminated."

There are many brazing and soldering operations now performed by other methods which could be done faster and better by high-frequency induction heat, Mr. Jordan points out.

"Induction heat can best be explained by likening it to the radiant heat from the sun," the engineer explains. "The sun's rays pass through space with little loss, yet when they strike a dark body the surface is heated. In like manner, the high-frequency pulsating magnetic waves, radiated from the induction heater coil, pass through all insulating materials with little loss, yet create heat when they strike any metallic body. In use, the part to be heated is placed in a water-cooled, copper tubing coil and current is passed through the coil at frequencies in the order of 500,000 cycles per second. This current generates the pulsating magnetic field which heats the part. The intervening air, or parts of the human body which may be in the magnetic field, are not affected."

SHIPBUILDING—"LIBERTY" SHIPS

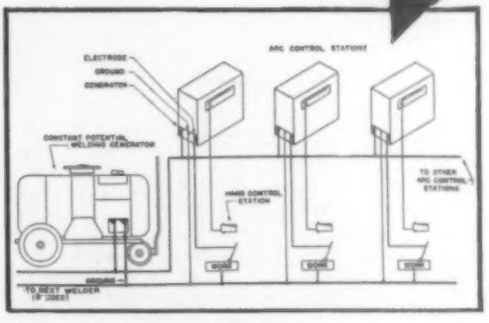
Welding is one of the most important advances in shipbuilding during the present century, with the torch resulting in immense savings in time, material and weight in the building of ships. This welder is joining side plates to angle frames forming sections of the propeller shaft tunnels on a new member of Uncle Sam's "Liberty fleet," under construction at a large Eastern shipyard. All parts are prefabricated in this huge Eastern plant which formerly turned out freight cars. The completed sections are then carried six miles to the ways on flat cars. *Oem Photo by Palmer.*

DELAND POOL: AIRCRAFT CONSTRUCTION CLASS

These two Daytona Beach, Fla., housewives talk over war work and welding like their grandmothers talked about the weekly quilting society, as they learn to take their places on a war production line in the Volusia county vocational school. Mrs. Nancy H. Herbert, left, has a son in the Navy. Mrs. Anna E. Larrabee, right, is a grandmother, who has one son in the Navy, a second in the Marines, a third in the Canal Zone as a war worker, and a fourth son who is now an aviation mechanic. *Official Owi Photo by Hollem.*

More Arcs FROM EVERY WELDING MACHINE...

with the New WILSON "HONEY BEE" Arc Control Station



GREATER welding output from every machine, improved arc control, and better welds on light or heavy gauge metal – these are some of the advantages offered by the new Wilson "Honey Bee" Arc Control Station. Several welding operations can be performed simultaneously from one constant potential arc welding generator – up to the full capacity of the generator.

For example, two 150 ampere or four 75 ampere Wilson "Honey Bees" can be connected to any 300 ampere constant potential generator. Most conventional drooping voltage generators can be converted easily to constant potential.

Operators at each "Honey Bee" station have full control over their individual welding currents. Infinite adjustments of current may be made by means of a remote control switch which may be combined with the electrode holder. Wilson Crater Control fades out the arc slowly to prevent weld defects that result from an abruptly broken arc. The Wilson "Honey Bee" is made in two sizes – 75 ampere and 150 ampere. For further details write for bulletin ADW-47.

WILSON

WILSON WELDER and METALS CO., INC.

General Offices: 60 East 42nd Street, New York, N. Y.

NEW PRODUCTS

The Society assumes no responsibility for the validity of claims in this Section

HARD SURFACING OF WORN PARTS

Increased war production is taking its toll on plant machinery and equipment, thus wear and tear are rapidly increasing. Difficulties in replacing these worn parts result in a heavy demand for more efficient methods of salvaging. The new Castolin DURFACE (*Dur*able Sur*fac*ing) line is designed for all-purpose rebuilding of worn parts and equipment at low temperature, with high-wear properties in the new added metal, thus enabling to prolong the life indefinitely of vital material.

Metals on Which DURFACE Can Be Applied: Steel, manganese steel, alloy steel, cast iron, malleable iron.

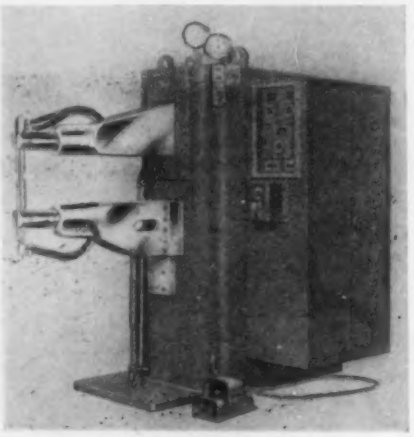
Composition: Ferrous base alloyed with hardening elements such as nickel, molybdenum, etc. Available bare for torch application and coated for d.-c. and a.-c. application. The chemical coating for d.-c. and a.-c. application does not affect the hardness.

For details communicate with Eutectic Welding Alloys Co., 40 Worth St., New York, N. Y.

ROCKER-ARM RESISTANCE WELDER

Sciaky Bros., now offer a new rocker-arm resistance welder, Type PMCR.2S16 for the spot welding of aluminum and its alloys. This machine embodies all of the Sciaky features found in their regular line, such as "Stored Energy with Preheating and Variable Pressure with Recompression." It also offers several unique advantages over conventional type welders. These features include adjustable electrode tips which may be set at any angle without impairing their proper welding position. Such settings make possible the welding of unusual shapes and sizes of metals which heretofore could not be welded with ordinary welding machines. Another Sciaky feature (see illustration) is that all gages and dials are visible to the operator and are set on the frame of the machine. This makes possible greater flexibility in operation when using a wide range of shapes and designs as mentioned above.

The welding process incorporated in this rocker-arm welder compensates for the natural expansion that takes place when the metal is in the molten state during the welding process. The Sciaky process of resistance welding as exemplified in the new rocker arm preheats the metal tending to overcome high thermo conductivity, thus slowing down the cooling process, and provides an added protection of a "forging" pressure which in itself precludes the possibility of shrinking the metal after



the weld. This rocker-arm machine provides the same weld settings as those embodied in the standard type Sciaky welders. Thus the operator of one machine can readily operate the other with exactly the same training, since the welding charts are applicable to both. This machine supplies a total pressure of 3000 lb. between the electrode tips from a supply line of 90 lb. using normal throat depth of 34 in. It has a welding capacity of 0.080 in. plus 0.080 in., 24ST Alclad. Welding stroke $^1/_2$ in. and retraction stroke $3\,^1/_2$ in. A special face plate at 45° can be incorporated with the vertical face plate for special work.

SOLDERLESS CONNECTORS AND LUGS FOR WELDING CABLES

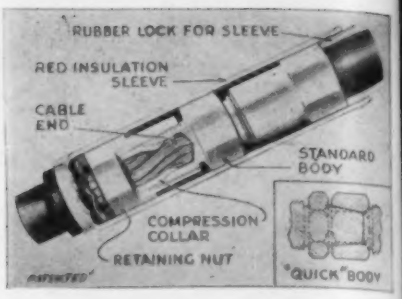
Ease and speed of shop or field installation, complete safety, full protection of cables and the conservation of vital materials are the principal advantages of the new Cable-Tite connectors and lugs for welding cables.

The body of standard Cable-Tite connectors is one piece as shown in the large illustration. The "quick" models, recommended for use where the whip-end and main cables connect, have a two-piece body, as shown in the line drawing. A slight twist while connecting locks the body into one unit.

Soldering is entirely eliminated—saving material, labor and time. To install a Cable-Tite in the shop takes but two or three minutes; in the field takes only five minutes.

After initial installation, cable lengths may be connected or disconnected by hand. Nut swivels so that cable is not twisted.

Ease of connecting and disconnecting makes it practical to switch cable lengths



periodically so that wear is uniform, thereby increasing cable life.

Cable-Tite fittings are available in various sizes.

Descriptive literature on Cable-Title fittings is available by writing to National Cylinder Gas Company, 207 W. Wacker Drive, Chicago, Ill.

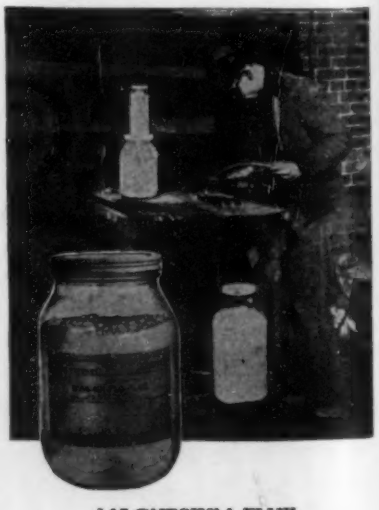
HARD-FACING ELECTRODES

The American Agile Corp., 5806 Hough Ave., Cleveland, Ohio, announces its newest welding electrode development; the Silver Series Electrodes. These electrodes are the answer to the present tool steel and die salvaging problem. The Agile Silver Electrodes eliminate waste inasmuch as a new and excellent cutting edge can be rebuilt to the worn tool shank. After the weld deposit is made, the tool is reground and goes back into actual use.

Other Agile Silver Electrodes are designed for the salvage of worn trimming dies, forming dies, punch dies, etc. They can also be used for the forming of new dies.

The Agile Silver Series also includes a chisel steel electrode that forms a chisel cutting edge that will withstand the hardest impacts.

Agile Silver Electrodes cover a range from 40–70 Rockwell C. Their uses are varied and very flexible and they can be applied with the usual welding technique with a.-c. or d.-c. welding machines.



MAGNESIUM FLUX

Park Stewart, 1061 Carbis St., Worthington, Pa., announces a new flux for the

PRECISION POWER TUBES FOR EVERY PURPOSE MADE BY UNITED

Skills in Electronics

When the war ends, there will be a phenomenal expansion in the peace-time use of electronics. Today—while the war absorbs the tube output—try to fix in your mind this unique source for tubes which you will seek tomorrow:

Its name: UNITED. Its organization: a group of eminent engineers and technicians, uniting their highly specialized skills. Its product: power tubes, unsurpassed in precision, for every electronic requirement including radio communication, physiotherapy and industrial control. Its standard: power tubes that consistently attain the highest record in every test of performance. Remember the name "United."

UNITED ELECTRONICS COMPANY

NEWARK, NEW JERSEY

gas welding of magnesium. This new flux known as "Mag-Na-Flo" Flux is suitable for gas welding all alloys of magnesium whether sheet or extrusions.

The manufacturer suggests that Mag-Na-Flo Flux be mixed to a thin paste by slowly pouring flux into water while stirring. Mix only enough for immediate use as the flux will crystallize if allowed to stand more than 10 to 12 hr. For best results it is suggested that the user paint the metal to be welded, with the flux, using a small brush. It is also advisable to coat the welding wire by dipping it into a tube of Mag-Na-Flo Flux prepared as previously suggested.

Mag-Na-Flo Flux is packaged in glass containers, which prevent corrosion and protect the flux from moisture, and is available in a large number of sizes ranging from 1/4 lb. to 25 lb. The manufacturer will furnish complete information on request.

GLAMOR IN THE WELDING SHOP

A complete line of tailored protective clothing for women welders, described as the first of its kind to be really styled according to accepted dressmaker patterns, is announced by American Optical Company of Southbridge, Mass. Made of specially selected chrome tanned cowhide, the new clothing is light in weight, yet gives positive protection against dangerous flying sparks.

Eliminating the necessity of wearing shapeless, uncomfortable protective clothing, the new AO tailored style is cut to afford free and easy movement of the body, but at the same time fits so snugly that there are no gaps or openings to permit entrance of flying sparks. The complete line consists of a tailored cap, short jacket, coat, overalls, sleeves and a 36-in. tailored apron. A descriptive catalog is available on request.

Seams of AO tailored protective clothing wherever possible, are located away from the direct line of fire. Welted in seam construction is used throughout for extra strength and to protect the stitching from hot sparks. Welted seams also add a note of smartness.

To protect women's hair and ears during the welding operation, AO stylists have designed a special tailored cap. It is made of chrome tanned leather, shaped somewhat like a bathing cap, with flaps extending over the ears. It is fashioned to cover the hair and hold it snugly and comfortable in place.

The overalls are styled like women's slacks. A side placket insures a trim, comfortable waist line. The flared trouser legs provide additional protection for the feet and make the garment easy to put on and take off over women's safety shoes.

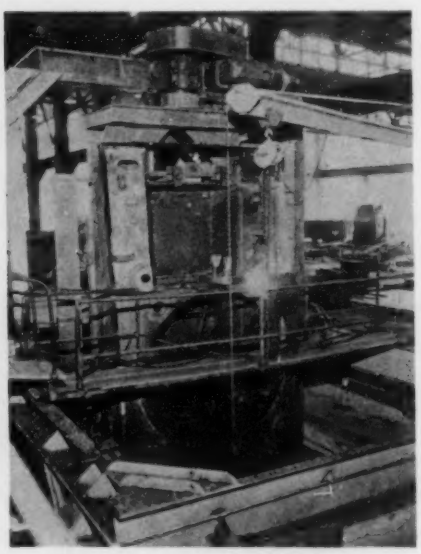
GIANT JIGS

"Jig time" might be a lively tune, but it most accurately describes a new, speedy welding development of the Pullman-Standard Car Manufacturing Company arsenal—the "jig" is a ponderous, intricate framework weighing 14 tons.

This giant device rotates the hull of a 30-ton M-4 tank upside-down and end-over-end so that all welds on the thick armor plate can be made from a fast and easy down-hand position. So versatile are the jigs that not a single verticle or overhead weld is necessary in the complicated task of hull fabrication.

The significance of this achievement may be gaged by the fact that Pullman-Standard is saving hundreds of man-hours in tank manufacture.

These jigs represent three months of intensive work by a staff of welding experts for the company under the direction of William Boese. Boese, who began welding in 1921 at the company's Michigan City, Indiana, freight-car works and who welded the first center sill in the history of railroading, says that "the company's pioneer experience in welding heavy freight-car underframes made the speedy process for tanks possible."



This Is One of the Big Jigs Rotated to the Vertical Position. Note Workmen on Cat-Walk Welding a Seam

The jig, or fixture (the terms are almost interchangeable), for tank welding consists of two parts—a truck and a jig proper. The latter is supported by the truck and holds the hull plates in position for welding.

The truck is a heavy steel frame, 15 X 24 ft. in size, mounted on four railroad car wheels which run on a broad gage track.

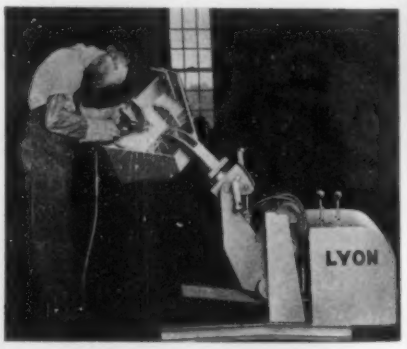
The jig proper, which holds the tank hull, is suspended within the frame from ball-and-socket-like joints and be easily rotated to any position so that the weld metal is always directly above the seam to be welded.

Boese said the jigs enable relatively inexperienced welders to work on tanks.

In addition, Boese pointed out, welding has eliminated much of the time required for machining and grinding the armor plate in each tank in preparation for riveting.

HYDRAULIC ELEVATING WELDING POSITIONER

The Lyon Hydraulic Elevating Welding Positioner, manufactured by Lyon-Raymond Corp., 1138 Madison St., Greene, N. Y., has a hydraulic tilting and hydraulic elevating table powered by a motor driven hydraulic pump and revolves in any position mechanically by worm gear arrangement. This unit has a capacity of 2000 lb.

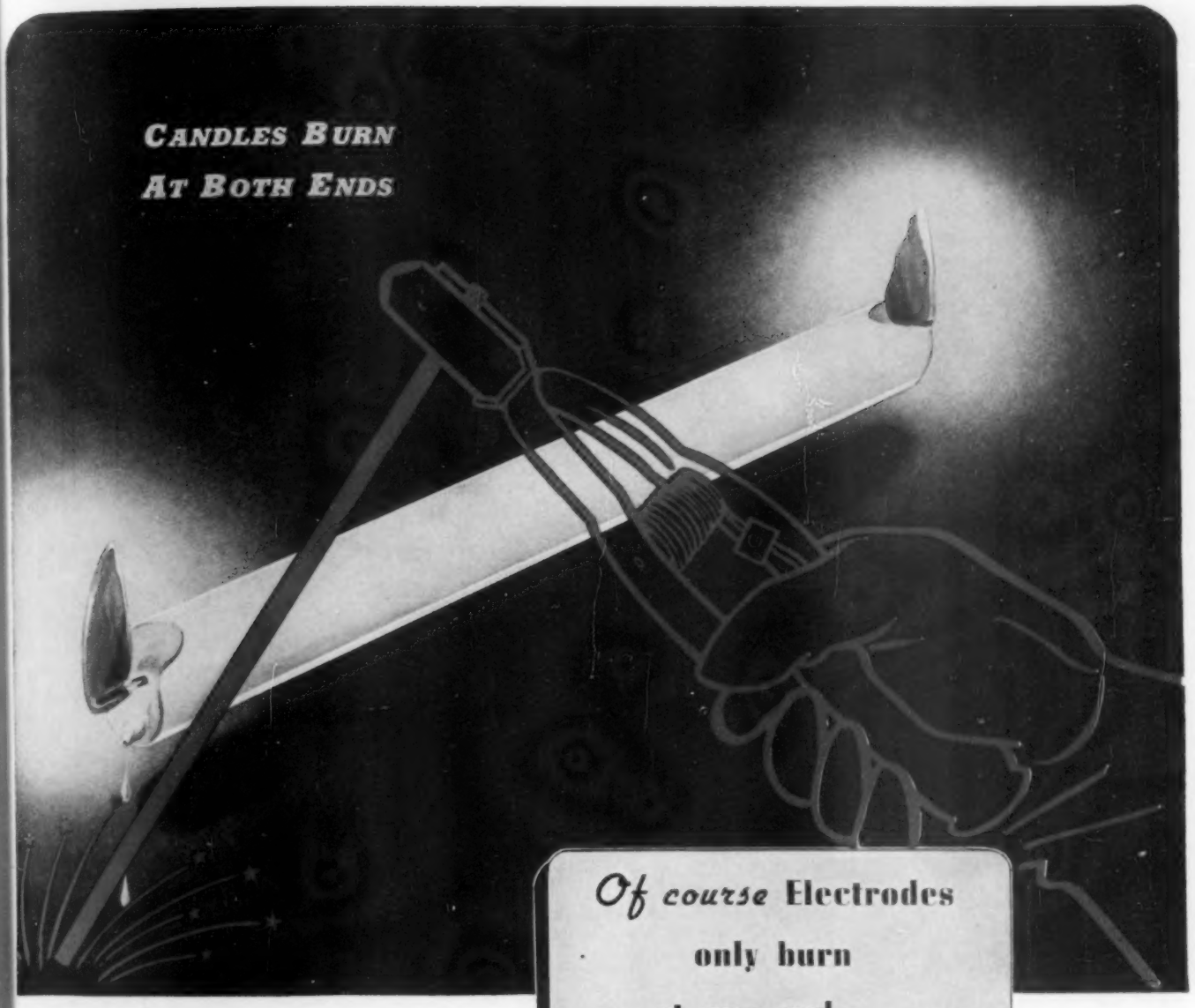


Due to the worm and worm gear, it is self-locking at any point within its revolution.

This company can also build welding positioners to handle heavier loads and larger material and with even greater flexibility of positioning.

ARC-TIME TOTALIZER

The Arc-Time Totalizer, a new development of the Hewlett-Packard Co., Palo Alto, Calif., is a boon to the users of welding equipment. West Coast shipyards are finding them particularly useful in providing accurate data for production control and better utilization of equipment, as well as giving a basis for bonus pay to welders. This instrument gives an accurate and inexpensive check on production by recording the cumulative time actual welding is being done. It will



Engineers and fabricators find our new catalog a valuable addition to their library on welding equipment. It contains charts and data of current interest. Let us send a copy.

Yet the waste represented by throwing away stubs in excess of two inches totals a surprising amount of material. Material which is scarce —vital to the war program. The operator who uses the maximum utility length and size of an electrode does a service to his employer and his country.

Champion Welding Electrodes produce clean, smooth welds at top speed production. There is a size and style for every job. The skilled welder and the apprentice operator find them easy to handle, satisfactory in performance. Use Champions on that next job—and be assured they will live up to their name.

THE CHAMPION RIVET COMPANY

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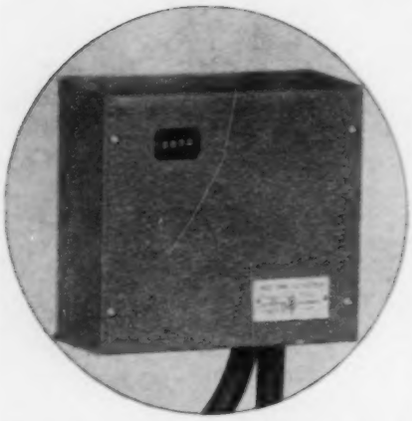
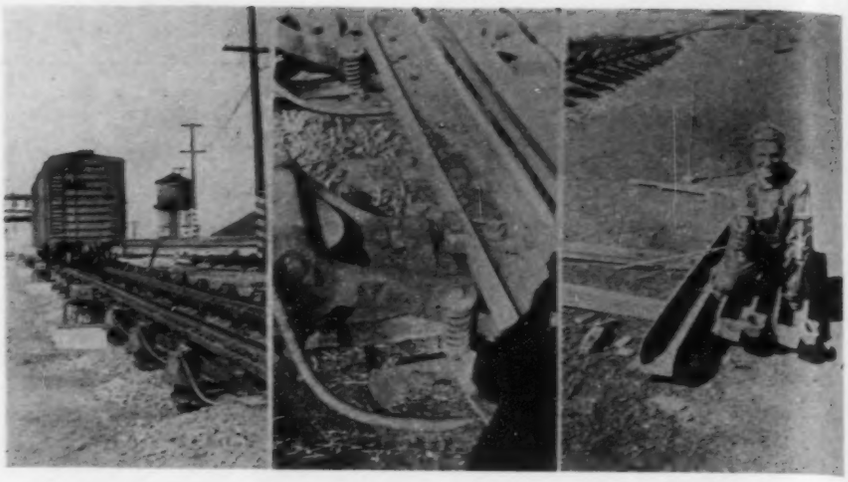


not register when the rod is shorted to the work. Time is recorded in tenths of hours on a scale which gives a reading up to 9999.9 hr. The instrument is mounted in a small, compact, steel box which can be easily attached to welding motor-generator sets. There are leads for connections to the welding current supply and terminals for easy connection to the power supply.

There are two models available: a model 1001A which registers the total welding time only and the model 1010A which is equipped with an automatic starter for the generator. This latter model is particularly useful when intermittent welding is being done or when only one or two welders are working from a single generator set. Thus the generator is shut off during the time no actual welding is being done, and can be started again by simply shorting the rod to the work.



HARD SURFACING WELDING ROD

A Middle-Western railroad operating a "hump yard" which handles hundreds of freight cars daily the year round has found in Amsco No. 459 a means not only of saving maintenance time and money, but of conserving vital metal for the war effort.

As a car rolls along by gravity toward one of the "make-up" tracks, a retarder unit exercises a braking action, stopping or slowing up the car at the proper spot. The bolts in these units, adjustable to compensate for wear on the friction shoes, take a terrific beating from frequent heavy impacts as do the sockets in which the bolt heads are seated. Bolt replacements were proving an expensive item.

Then a set of worn bolts was built up with high carbon rod and hard surfaced with Amsco No. 459, and it was found that the restored bolts gave four or five times as much service as was obtained from ordinary heat-treated bolts.

In the accompanying illustrations, the one at left shows the complete retarder unit; the center, a close-up of the socket in which the bolt heads are seated; and at the right, retarder bolts "before and after" restoration with this welding rod. For details write to American Manganese Steel Division, Chicago Heights, Illinois.

SECTION ACTIVITIES

BOSTON

About 150 members and guests attended the November 16th meeting of this section and saw three reels of the General Electric Company's technicolor film "The Inside of Arc Welding."

On December 14th, the Section held its meeting at the Engineers' Club, Boston—with dinner at 6:30 P.M. and the program starting at 7:45 P.M.

The topic of this evening, "Unionmelt Welding," was presented by Mr. J. M. Keir and the discussion leader was Mr. Norman Schriener, both coming from the New York office of The Linde Air Products Company.

CHICAGO

On October 28th the members of the Chicago Section, AMERICAN WELDING SOCIETY, their friends and those interested in welding were guests of the Machinery Welder Corporation, Chicago, at the showing of "The Inside of Arc Welding." This meeting, which was the first public showing in Chicago of this popular General Electric film, was an overwhelming success.

The meeting was one of the largest ever held in Chicago in connection with welding activities. More than 450 persons saw the picture and many more were disappointed because of their inability to gain admission to the Auditorium.

R. D. West, Superintendent of the Hull Department, Manitowoc Ship Building Company, was the guest speaker at the November meeting of the Chicago Section, AMERICAN WELDING SOCIETY.

"Submarine Welding" was the subject of the paper presented November 20th at the Electric Club Auditorium. In his paper the speaker presented in a very interesting manner the highlights of welding in connection with the building of submarines. The paper was of unusual interest because it described the methods used in the first inland shipyard to undertake the building of submarines in this country. Because of censorship restrictions it was necessary for the speaker to omit several interesting phases of the operations, which would have been of considerable interest to the listeners.

This meeting was preceded by a dinner and the showing of Pan American Airways' film, "Skyway to Hawaii."

The next meeting of the Chicago Section was held December 18th, at which time a paper entitled, "Improved Methods of Machine Cutting," was presented by John A. Rea, The Linde Air Products Company.

CLEVELAND

The regular meeting of the Cleveland Section was held at the Cleveland Engineering Society Building, Wednesday evening, December 9th. The program featured inside information on the welding of liberty ships and a coffee talk.

Mr. E. B. Williams, Vice-President of Delta Shipbuilding Company of New Orleans (subsidiary of American Ship Building Company) spoke on the subject

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WHERE would modern War Production be without hand or machine cutting torches?

The greatest shipbuilders of America are utilizing VICTOR Hand and Machine Cutting Torches because they have proved themselves of longer service life and of greater cutting ability.

VICTOR is proud that 100% of its products are engaged in Victory Production.

VICTOR EQUIPMENT COMPANY

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of "Welding of Liberty Ships." His discussion dealt with the conception and construction of these ships at the Delta Shipbuilding Co., which plant was specially built for the construction of all-welded ocean-going cargo ships. He also briefly outlined the original design of the U. S. Maritime Commission EC-2 cargo vessels (Liberty Ships) and how this design has been applied at this plant. He dwelt to some extent on the necessity of coordination between design and operations, emphasizing the necessity of practical considerations in welded ship design.

The coffee talk after the dinner consisted of a sound film, "Men of the Coast Guard" with comments by Ensign W. G. Smith.

The Cleveland Section now enjoys the distinction of being the sixth largest in the country, with a membership of 265. The following are new members who have recently been welcomed to this Section: John E. Adams, Lawrence H. Dunham, J. R. Thompson, Ian R. Sutherland, Oscar S. Swanson, Cecil C. Peck, Anthony P. Sulak, Frank W. May, Jack J. Berlin, Wm. Bumblis, Frank M. Gall, J. J. Jarms, Rolla B. McCashen, Wm. M. Myers, Leonard C. Pfabe, T. T. Priesland, Robert C. Sessions.

The program for 1943 includes the following current subjects of great importance: "Planning for Production Cutting, Welding and Heating in West Coast Ship Yards;" "Stainless Steel Welding;" "Resistance Welding;" "Welding in Aircraft." The Annual Welding Symposium will be held in May.

COLUMBUS

The November meeting of the Ohio State University Student Branch of the Columbus Section of AMERICAN WELDING SOCIETY was held November 16, 1942, at the Ohio Union on the campus with Clarence Shultheis, president, presiding.

Professor Stitt, faculty adviser, announced that the By-Laws Committee of the National Headquarters of the AMERICAN WELDING SOCIETY has recommended a set of By-Laws for student chapters. The By-Laws of the Ohio State student chapter are similar to those recommended.

Mr. Robert D. Williams of Battelle Memorial Institute gave a very interesting talk on "The Advancements in Welding Through Metallurgy."

CONNECTICUT

The Connecticut Section held an informal dinner meeting at New Haven on November 24th. The dinner was followed by a round table discussion of welding problems. Several more such meetings were scheduled for the near future.

DETROIT

The Flint Division held two meetings on December 3rd—a noon session as well as an evening session—both were very well attended. Mr. Leon C. Bibber of the Carnegie Illinois Steel Corporation spoke at both sessions on the subject of "Fundamentals in Arc Welding." Mr. Bibber stressed metallurgical considerations and did a most marvelous job.

The Detroit Group met on December 4th. Mr. A. H. Yoch, Welding Engineer, Air Reduction Sales Company, presented a paper on "Flame Hardening and Cutting in Ordnance Work." He gave an excellent talk on the practical considerations involved. Dr. Armand DiGiulio, Research Metallurgist, Bundy Tubing Company, spoke on "Methods of Brazing." He reviewed quickly the history of brazing, developed the subject of fluxes very well and then discussed the several types of brazing.

MILWAUKEE

The November meeting of this Section was held on the 27th. Mr. J. G. Magrath of the Applied Engineering Department, Air Reduction Sales Company, presented the welding address on "Production Welding and Cutting at West Coast Shipyards." The talk included a presentation of slides and discussion of the correlated facilities of supply, distribution, control, education and procedures for the Maritime Commission's Liberty ship high-speed production.

An after dinner feature was the showing of a motion picture, "Fishing Trip in Canada," by Raymond Herr of the Harnischfeger Corporation.

NEW YORK

The New York Section of the AMERICAN WELDING SOCIETY held its regular monthly technical meeting on December 8, 1942, at the Engineering Society's Building. Technical chairman for the evening was O. T. Barnett, Assistant Production Engineer, Welding Division, Metal and Thermit Corporation, New York, N. Y.

The speaker for the evening was Mr. H. Malcolm Priest, Engineer, Railroad Research Bureau, U. S. Steel Corporation Subsidiaries, Pittsburgh, Pa., who spoke on the subject, "Engineering Essentials for Welders." In his paper Mr. Priest presented, in non-technical terms, information on the engineering aspects of welding. Included in his talk, which was accompanied by numerous lantern slides, was a discussion of such factors as the physical and metallurgical properties of steel, forces and stresses, welding, design, bending, temperature effects and fatigue strength. The paper dealt with the engineering aspects of many of the problems encountered daily by the welding operator when depositing weld metal.

Following Mr. Priest's talk, the second three reels of the all-color, sound motion picture, "Fundamentals of Arc Welding," were presented by Mr. E. Vom Steeg, Jr., through the courtesy of the General Electric Company. These films included: (1) flat and horizontal position welding with a. c.; (2) vertical position welding; (3) overhead position welding.

The evening opened with a half-hour question and answer period conducted by H. R. Morrison, The Linde Air Products Company, New York, N. Y.

NORTHWEST

Mr. George L. C. Dehn, Field Engineer of the Magnaflux Corporation, spoke on "The Principles of Magnaflux Inspection" at the December 15th meeting of this Section. "X-Ray and Gamma-Ray Inspection" was discussed by H. F. Scobie, Instructor in Mechanical Engineering, U. of M., at the fourth meeting of the Welding Clinic held on December 17th.

OKLAHOMA CITY

A Liquid Air Demonstration was given by Mr. M. G. Wicker, District Manager of Air Reduction Sales Company at the December 3rd meeting of the Oklahoma City Section. The latest movie by the United States Steel Corporation was also shown. The Section has been making every effort to make the meetings attractive for the operator and welding supervisor. The attendance shows that interest has been aroused on the part of these men.

A 16 weeks' course on "Welding Theory and Design" is being given by Mr. William T. Tiffin, local member from the University of Oklahoma, assisted by Howard N. Simms, of Black, Sivalls & Bryson, Inc.

PHILADELPHIA

The meeting held on October 19th, was opened with the showing of Reel No. 3 of the series of six entitled "Inside of Arc Welding" being shown consecutively through the courtesy of Mr. O. J. Pearre of the General Electric Company.

Following the picture, Mr. J. G. Magrath of the Air Reduction Sales Company spoke extensively on "Cutting and Welding on Liberty Ships" in conjunction with a group of slides on the same subject which were selected at random from shots taken in seven West Coast shipyards. Mr. Magrath pointed out that, while the talk was entitled "Cutting and Welding on Liberty Ships," not all of the pictures were those from yards building this particular type of ship, and the object of the entire talk was to stress the procedure for which these yards are striving rather than the actual building of the ship. In this connection, before going into the series of pictures showing actual operations throughout the yards, Mr. Magrath followed the course of material through the plan of a modern "Assembly Line" yard, commenting at length on its comparison with the type of yard now operating in the Philadelphia area.

A splendid discussion developed, after the completion of Mr. Magrath's talk.

The War Production Committee is planning on holding a series of panel discussions at the Broadwood Hotel on Monday afternoon, January 18th, at about 4:00 P.M., designed to offer as much information as possible to the foremen and directors of small shops and plants to whom the most current developments in engineering are not immediately accessible. Each of the various local societies was assigned a topic for panel discussion, the A.W.S. topic being the "Conservation of Oxygen, Acetylene, Electrodes and Electric Power."

Quick, easy tests for qualitative identification of some common white metals and alloys

The following procedures will distinguish among Monel, "S" Monel*, "K" Monel*, Nickel, 30 per cent copper nickel, nickel silver, Inconel*, chromium-iron and chromium-nickel stainless steels, Ni-Resist*, ordinary steel, and cast iron. Before testing, the material should be cleaned with emery cloth or a file to remove dirt, grease or corrosion products, or any metallic coating such as galvanizing.*

Test with a Strong Horseshoe Magnet

1. If the material is strongly magnetic, it may be nickel, ordinary steel, cast iron or chromium-iron stainless steel. Confirm as in Procedure A.

2. If the material is slightly magnetic, it probably is Monel† or cold-worked 18-8 stainless steel with or without molybdenum. Confirm as in Procedure B or heat the specimen in hot water, preferably boiling, and retest with a magnet while hot. If the specimen loses its magnetism when heated it is MONEL.

3. If the material is non-magnetic, it may be copper nickel, nickel silver, "K" Monel, "S" Monel, Inconel, chromium-nickel stainless steel with or without molybdenum, or Ni-Resist. Confirm as in Procedure C.

Procedure A

FOR STRONGLY MAGNETIC MATERIALS

Place a drop of concentrated nitric acid on a cleaned area.

1. If the acid reacts slowly to a pale-green color, the material is NICKEL.

2. If the acid reacts slowly to a brown-black color, the material is either ORDINARY STEEL, LOW-ALLOY STEEL or CAST IRON.

3. If no reaction occurs, the material is CHROMIUM-IRON STAINLESS STEEL.

Procedure B

FOR SLIGHTLY MAGNETIC MATERIALS

Place a drop of concentrated nitric acid on a cleaned area.

1. If the acid reacts to a green-blue color, MONEL is indicated.

2. After reaction has ceased, add one or two drops of water, immerse an iron nail or steel knife blade in the drop and in contact with the test sample. If the nail or knife blade becomes coated with copper, or if a copper deposit appears on the material being tested, the latter is MONEL.

3. If no reaction occurs, the material is heavily cold-worked CHROMIUM-NICKEL STAINLESS STEEL.

Procedure C

FOR NON-MAGNETIC MATERIALS

Place a drop of concentrated nitric acid on a cleaned area.

1. If the acid reacts rapidly to a blue-green color, the material is NICKEL SILVER or COPPER NICKEL.

2. If the acid reacts to a green-blue color, the material is "K" MONEL or "S" MONEL. The form of the material will usually assist in identification since "K" Monel is never cast and "S" Monel is never wrought.

3. If the acid reacts to a brown-black color, the material is NI-RESIST.

4. If no reaction occurs, the material may be either Inconel or chromium-nickel stainless steel with or without molybdenum.

To distinguish between Inconel and the stainless steels:

(a) Place on the sample a few drops of a solution containing 10 gm. of cupric chloride ($CuCl_2 - 2H_2O$) in 100 cc. of concentrated hydrochloric acid and allow it to stand for 2 minutes. Then slowly add a few drops of water, one drop at a time, and finally wash off the solution. If a copper-colored spot remains, the material is CHROMIUM-NICKEL STAINLESS STEEL with or without molybdenum; if an uncolored etched spot remains, the material is INCONEL. Or

(b) Place 1 drop of concentrated hydrochloric acid on a clean surface of the alloy and allow it to react for 1 minute. Then add 1 drop of an acid ferricyanide solution containing 1 per cent by weight of potassium ferricyanide, $K_3Fe(CN)_6$, and 10 per cent by weight of sulfuric acid. If a dark blue color appears quickly, the material is CHROMIUM-NICKEL STAINLESS STEEL with or without molybdenum; if no color develops it is INCONEL.

(c) A distinction may be made between the types 316 and 317 stainless steel, which contain molybdenum, and the chromium-nickel types 302 and 304. The test is made by immersing the alloy in an aqueous solution containing 75 per cent by weight of orthophosphoric acid (H_3PO_4) and 1 to 30 gm. per liter of sodium chloride (common salt) at 140° to 200° F. If the stainless steel does not contain molybdenum (Types 302 or 304) bubbles of hydrogen will begin to form within 30 sec. If the alloy contains molybdenum (Types 316 and 317) bubbles will not form. The quantity of sodium chloride and the testing temperature are not critical within the limits indicated.

*REG. U. S. PAT. OFF.

†This test should be made preferably after cooling the metal with ice water or a freezing mixture, which will increase the magnetic strength and permit easier distinction between Monel and nickel-copper alloys of lower nickel content, e.g., nickel silver.

THE INTERNATIONAL NICKEL COMPANY, INC., 67 WALL STREET, NEW YORK, N.Y.

★ ★ INCO NICKEL ALLOYS ★ ★

MONEL • "K" MONEL • "S" MONEL • "R" MONEL • "KR" MONEL • INCONEL • NICKEL • "Z" NICKEL

Sheet...Strip...Rod...Tubing...Wire...Castings

Attention of the members of the Philadelphia Section is called to the fact that the above meeting occurs on the third Monday of the month, the usual meeting night, and will necessitate a change in plans of the Section.

PITTSBURGH

One hundred fifty members and guests attended the November meeting of the Pittsburgh Section to hear a discussion by Harold N. Ewertz, Sales Manager, Arcos Corporation, of Philadelphia, Pa., on the subject "The Welding of Air Hardenable Steels." Differences in the effects of welding low-alloy hardenable steels with various electrodes were pointed out by the speaker, covering both the weld metal and the fusion and heat-affected zones. With the use of slides Mr. Ewertz gave a most complete presentation of the subject, following which the meeting was thrown open for discussion and many questions from those present were answered.

The second and third reels of the General Electric Company's color sound film, "The Inside of Arc Welding," were then shown, following which the meeting was adjourned.

Following the usual custom no meeting was held in December.

ROCHESTER

The regular monthly meeting of the Rochester Section was held on December 3rd at Todd Union, University of Rochester. Dinner preceded the meeting. Mr. Gomer Stelljes of W. C. Sykes Co., and Mr. Kent Wood, Field Supt., Socony-Vacuum Oil Co., gave their experiences on the subject of "Pipe-Line Welding, Acetylene and Electric Arc." "Cannons on Wings," a sound-Kodachrome picture, was shown through the courtesy of Bell Aircraft Corp.

SAN FRANCISCO

The November meeting of the AMERICAN WELDING SOCIETY, San Francisco Section, was held at the Athens Club, Oakland, Calif., on Friday, November 20, 1942.

There were approximately 55 members and guests in attendance.

In the absence of the Chairman, Mr. Frank Longo, who was in Portland, Ore., the Program Committee Chairman, Mr. R. O. Waldman, presided.

The minutes of the October meeting were read and approved as read.

Mr. Pat Doggett, of the Moore Dry Dock Company, discussed at length his personal experience with women welders and burners in the shipbuilding industry. Mr. Doggett's remarks were very enlightening and to many of us were quite surprising, as Mr. Doggett had nothing but good to report about his lady welders and burners, of which he has quite a few.

Following this discussion, through the courtesy of the Pacific Gas and Electric Company, the sound motion picture entitled "Whirling Wheels," narrated by John B. Hughes, depicting Industry in Northern California, was shown. This picture was very interesting and quite enlightening to everyone.

WASHINGTON

The November meeting was held at the Potomac Electric and Power Company Auditorium. Mr. W. S. Loose, Metallurgist of the Dow Chemical Company, spoke on the subject of "Welding of Magnesium Alloys as Applied to Industry." Mr. C. E. Jackson presented a most unusual exhibition of magic which was thoroughly enjoyed by members and guests.

The December meeting which was a joint meeting with the Washington A.S.M. Chapter, was addressed by Mr. Harry W. Pierce, nationally known authority on ship welding from the New York Shipbuilding and Dry Dock Company. Mr. Pierce talked on "Stresses in Large Welded Structures," particularly as applied to ships. His comprehensive thought and experiences with this subject were of great interest to the members present.

YORK-CENTRAL PENNSYLVANIA

The November meeting, held on the 18th, at the Engineering Society Building, was addressed by Mr. H. C. Esgar, Sales Engineer of the Stainless Division of Carnegie Illinois Steel Corp. Mr.

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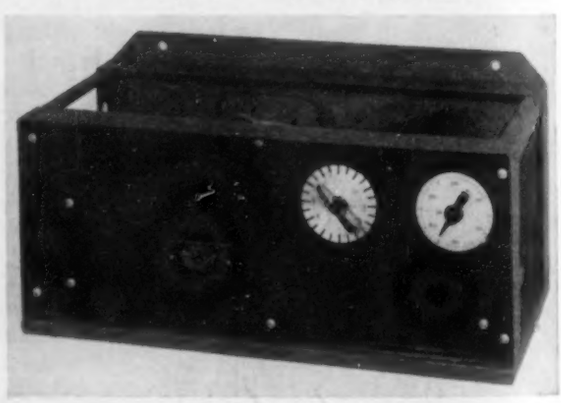

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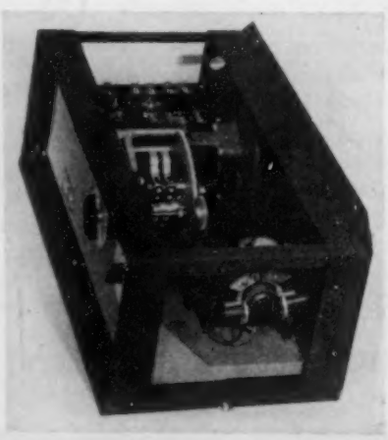

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Esgar spoke on "Welding of Stainless Steels," which covered the classification of this grade of steels and their behavior when subjected to the various welding processes.

Employment Service Bulletin

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OBITUARY

Chester F. Gailor

Chester F. Gailor, for many years a sales engineer with offices at 30 Church Street, New York, died Dec. 15th at his home at 58 East Seventeenth Street, Brooklyn, after a heart attack.

Mr. Gailor was born on April 23, 1881, at Mechanicville, N. Y., and was graduated in engineering at Rensselaer Polytechnic Institute. He served as a lieutenant colonel in the construction division of the United States Army Engineer Corps in the First World War. After the war he located in New York, specializing in the purchase of railway equipment.

He leaves a widow, a brother, D. Floyd Gailor of New Haven, Conn., and two sisters, Mrs. William McDermott and Mrs. Roy Dunn of Mechanicville.

Mr. Gailor was a member of the AMERICAN WELDING SOCIETY since February 1922.

HOW TO SALVAGE TOOLS

A very attractive poster showing complete procedure for salvaging every type of tool vital to the War Program has been prepared by the Eutectic Welding Alloys Co. Copy may be obtained upon request of the company at 40 Worth St., New York, N. Y.

List of New Members

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Chase, Frank W. (C), 25 Thompson St., So. Portland, Me.
Clark, Earl J. (C), 185 No. Common St., Lynn, Mass.
Cooper, Leonard W., (C), Falmouth Foreside, Town Landing, Me.
Haywood, Henry S. (B), Welder's Supply Co., 15 St. Mary's St., Boston, Mass.
Manzer, Clifford M. (C), General Elec. Co., 920 Western Ave., Bldg. 76, Lynn, Mass.
Mello, Daniel (D), 27 Bond St., Apt. 7, Lynn, Mass.
McCarty, John (C), Birch Knolls, Cape Cottage, Me.
Oltsch, Howard A. (D), Bethlehem Steel Co., Fore River Shipyard, Quincy, Mass.

CANADA

Granik, Albert (B), General Motors of Canada, Ltd., Oshawa, Ont., Canada.
McGrath, Paul R. (C), P.O. Box 860, Sorel, Que., Canada.
Willey, Gordon E. (B), 43–47 Queens Park, Toronto, Canada.

CANTON

Kerstetter, Ray E. (C), 1525—16th St. N.E., Canton, Ohio.

CHATTANOOGA

Kosik, John A. (C), 1156 Highland Dr., Chattanooga, Tenn.
Lehon, J. J. (B), 709 Chestnut St., Chattanooga, Tenn.
Stage, K. F. (D), Rt. 2, Hixon, Tenn.
Stevenson, G. D. (D), Rt. 3, Rossville, Ga.

CHICAGO

Sciaky, David (B), Sciaky Bros., 4915 W. 67th St., Chicago, Ill.
Steen, Hellmuth (C), 3003 N. Washtenaw Ave., Chicago, Ill.

CINCINNATI

Dannenfelser, Paul D. (D), 2851 Victoria Ave., Cincinnati, Ohio.
Feinthal, B. K. (B), 1106 Ryland Ave., Cincinnati, Ohio.
Hess, Louis J. (B), 5502 Stewart Ave., Cincinnati, Ohio.
Pollard, Raymond C. (D), 3407 Cardiff Ave., Cincinnati, Ohio.
Schuler, Carl J. (B), 2846 Claypole, Cincinnati, Ohio.
Turrill, Fred D. (B), Industrial Training Inst. Inc., 705–11 Sycamore St., Cincinnati, Ohio.

CLEVELAND

Barr, Glenn S. (D), Avon Lake, Ohio.
Boyer, Clayton (C), 199 Union St., Bedford, Ohio.

CONNECTICUT

Devine, Charles P. (B), Peerless Unit Ventilator Co., 810 Union Ave., Bridgeport, Conn.
Pitcher, F. J. (B), N.Y., N.H. & H. R.R., General Office, New Haven, Conn.

DETROIT

Bakeman, Morley F. (B), 204 W. Dayton St., Flint, Mich.
Baker, Richard (B), 4123 Kendall, Detroit, Mich.
Buckmaster, L. H. (B), Lincoln Elec. Co., 10228 Woodward, Detroit, Mich.
Burch, Guy E. (C), 3490 Lincoln Ave., Detroit, Mich.
Ciranko, Dazo H. (B), 512 Stockdale St., Flint, Mich.
Cotton, Arthur (B), 2955 Blaine Ave., Detroit, Mich.
Edelmayer, John (C), 5559 Joy Rd., Detroit, Mich.
Estep, Clair M. (C), 158 Northlawn, Detroit, Mich.
Evans, M. B., Jr. (B), 15894 Ashton Rd., Detroit, Mich.
Fisher, Edward (B), 2301 Hills St., Flint, Mich.
Fisher, Kenneth P. (C), 13207 Indiana, Detroit, Mich.
Galletti, Adam (D), Box 323, Dearborn, Mich.
Hacker, Randolph (D), 15036 Pierson Ave., Detroit, Mich.
Hassler, John (B), 2019 Whittemore, Flint, Mich.
Hengesbaugh, Bernard L. (B), 906 Garland St., Flint, Mich.
Hessler, Arthur (B), 19346 Tracey, Detroit, Mich.
Heusel, Robert J. (B), 3117 Sunset Dr., Flint, Mich.
Hillenbrand, Vincent E. (B), 3186 Grand Blanc Rd., Detroit, Mich.
Holm, Arthur H. (C), 3000 Carter, Detroit, Mich.
Hurley, John T., Jr. (C), 2548 Richards, Detroit, Mich.
Iapolucci, Francis (B), 20029 Amira, Detroit, Mich.
Jacobs, Wade P. (B), Fisher Body Corp., General Motors Bldg., Detroit, Mich.
Kelly, William (C), 11322 Winthrop, Detroit, Mich.
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Klingelhofer, Herman (B), 1060 Lafayette, Detroit, Mich.
Kovacevic, Peter M. (B), 3428 N. Belsey Rd., Grand Blanc, Mich.
Krecke, Karl N. (B), 1556 Chevrolet Ave., Flint, Mich.
Link, Henry (B), 1126 Pershing St., Detroit, Mich.
Manor, J. B. (B), 8928 Second Blvd., Detroit, Mich.
Miller, Edward (C), 1809 York, Dearborn, Mich.
McKitrick, Edward R. (B), 3871 Beniteau Ave., Detroit, Mich.
McMullen, Donald R. (C), 315 W. Woodbridge, Detroit, Mich.
Nielsen, Claudius (B), 19720 Florence Rd., Detroit, Mich.
Ray, Andrew J. (C), 22736 Arlington, Dearborn, Mich.
Vensas, Victor V. (B), 1322 E. 115th St., Cleveland, Ohio.

COLUMBUS

Wingert, Jesse H. (D), 1730 Rutland Ave., Springfield, Ohio.
Rogers, Howard L. (B), 4400 Belsey Rd., Grand Blanc, Mich.
Stoner, Roy C. (B), 1850 E. Gd. Blvd., Detroit, Mich.

Stutz, A. M. (B), Stinson Aircraft, Div. of Vultee Aircraft, Inc., Wayne, Mich.
Tahash, Gerald J. (B), 3512 Columbine St., Flint, Mich.
Van Belois, Gerald (B), 5138 Branch Rd., Detroit, Mich.
Wilcox, Milton L. (C), A. C. Spark Plug Co., Flint, Mich.

INDIANA

Combs, Oral (D), 1227 So. 22nd, New Castle, Ind.
Davidson, Lloyd H. (C), 2128 Indiana Ave., Connersville, Ind.

LOS ANGELES

Allen, Orville C. (C), 143 No. Herbert Ave., Los Angeles, Calif.
Babaz, George M. (C), 559 Kingbee, Downey, Calif.
Bewley, A. A. (C), 5611 Keniston Ave., Los Angeles, Calif.
Carter, Clyde B. (C), 2071 St. Louis, Long Beach, Calif.
Hall, Thomas C. (C), 121 W. Oak, El Segundo, Calif.
King, Frederic C., Jr. (C), General Petroleum Corp., 2525 E. 37th St., Los Angeles, Calif.
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Morrow, Jennings C. (D), 25832 Narbonne Ave., Lomita, Calif.
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Robbins, M. W. (C), 5812 Harold Way, Hollywood, Calif.
Thuet, Fred A. (C), 8996A Calif. Ave., Southgate, Calif.
Vanderwall, Leslie A. (C), 6414—7th Ave., Los Angeles, Calif.

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Scharf, Frederick (C), Koppers Co., 200 Scott St., Baltimore, Md.

NEW YORK

Bannerman, David B., Jr. (C), American Bureau of Shipping, 47 Beaver St., New York, N. Y.
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Pastorelli, Emil K. (D), 1410 Putnam Ave., Brooklyn, N. Y.
Ryan, Robert T. (C), American Bureau of Shipping, 47 Beaver St., New York, N. Y.

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McCann, James E. (D), 689 S. 18th St., Newark, N. J.
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Obrig, John T. (B), Cargodaire Engrg. Corp., 75 West St., New York, N. Y.
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Rini, Dale (D), 148 Kensington Ave., Apt. 203, Jersey City, N. J.
Routledge, George W. (D), 179 S. 48th St., Bayonne, N. J.
Rozycki, M. J. (C), 226—1st St., Jersey City, N. J.
Shields, William M. (C), 210—5th St., Jersey City, N. J.
Simons, Alexander (D), 625 Howard Ave., Brooklyn, N. Y.
Swearer, Harry L. (D), 60 Clinton St., Rahway, N. J.

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Maguire, James M. (B), 22 Sarren St., Glens Falls, N. Y.
Palmatier, Kenneth R. (C), General Elec. Co., Ind. Heating Dept., Schenectady, N. Y.
Sayles, Phil S. (C), General Elec. Co., Industrial Dept., Schenectady, N. Y.
Taylor, W. J. (B), General Steel Castings Corp., Eddystone, Pa.

NORTHWEST

Belisle, Lester E. (C), 1807 Flandrau St., St. Paul, Minn.
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Schmidt, Michael (D), 4225 Monroe St., N.E., Minneapolis, Minn.
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Wlaschin, Walter (C), 942 Conway, St. Paul, Minn.
Zimney, Philip J. (C), 394 Dayton St., St. Paul, Minn.

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Hargrove, Bernard (D), R.R. 1, Peoria, Ill.
Stanick, Herman (C), 505 Seneca War Homes, Seneca, Ill.

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Castner, Estol H. (D), 1826—68th Ave., Philadelphia, Pa.
Garcia, A. M. (B), Fox St. & Roberts Ave., Philadelphia, Pa.
Layton, John B. (C), 1232 Linden St., Wilmington, Del.
Smith, William F. (C), Dravo Corp., Ft. of Madison St., Wilmington, Del.

PITTSBURGH

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Keeney, John H. (B), 413 Orchard St., Sewickley, Pa.
McMillan, Clarence H. (B), Oliver Iron & Steel Corp., Muriel St., Pittsburgh, Pa.
Nutter, John K. (C), Williams & Co., 901 Penna. Ave., Pittsburgh, Pa.
Williams, H. E. (B), Williams & Co., 901 Penna. Ave., N.S., Pittsburgh, Pa.

PUGET SOUND

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King, George B., Jr. (C), 508 No. E St., Tacoma, Wash.
Lindsay, J. A. (B), Welding Dept., No. 1 Yard, Yarrow's Ltd., Victoria, B. C., Canada.

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Kay, Alan D. (D), 6951 Thornhill Dr., Oakland, Calif.
Maffei, Ray (D), 408 Taurus Ave., Oakland, Calif.
Reed, Howard B. (D), 8017 Earl St., Oakland, Calif.
Rhein, Reginald W. (D), 9847 Olive St., Oakland, Calif.
Rice, Allen M. (D), 1734 Bancroft Way, Berkeley, Calif.
Sanford, Jack C. (B), Victor Equip. Co., 844 Folsom St., San Francisco, Calif.

SOUTH TEXAS

Scharnberg, H. S. (D), 415—69th St., Houston, Texas.

WASHINGTON, D. C.

Howland, O. L. (B), % War Production Board, Welding Div., Temporary Bldg. E, Washington, D. C.
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Osgood, Elmer C. (D), 237—37th St., S. E., Washington, D. C.
Wilkinson, William M. (C), 4643—16th St., N.W., Washington, D. C.

WESTERN NEW YORK

Held, Clarence (C), 49 Geo. Urban Blvd., Buffalo, N. Y.
Jung, Earl A. (B), August Feine & Sons Co., 140 Terrace, Buffalo, N. Y.
Steward, C. Weston (B), 24 Morningside Lane, Williamsville, N. Y.

WICHITA

Helvey, O. C. (B), Cessna Aircraft Co., Hutchinson, Kans.

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Claytor, W. I. (B), Box 833, Bluefield, W. Va.
Gibbs, H. I. (B), Gibbs Welding Supply Co., 315—12th St., Des Moines, Iowa.
Griffin, Harry H. (D), 623 So. Rebecca St., Spokane, Wash.
Rees, E. R. (C), 300 N. Maple St., Somerset, Ky.
Thomason, Lawrence N. (B), 2408 Chamberlayne Ave., Richmond, Va.
Ulmer, Sherman (C), 3863 Southern, Memphis, Tenn.
Walden, Dane B. (B), 3406 S. Hanna St., Ft. Wayne, Ind.